STANDARD TAPERS.

A SIMPLE METHOD FOR PRODUCING AND DUPLICATING THEM.

C. C. STUTZ.

Some years ago I had occasion to make some taper plugs, which were to be used as standards for a certain class of machines. It was necessary that the method employed should admit of an easy and accurate reproduction of plugs furnished to customers without the necessity of keeping master specimens of plugs so furnished. This condition was imperative, as the

FIG. I. FIXTURE FOR TESTING TAPERS.

plugs were made to dimensions given by customers, and the expense of making, keeping and caring for a specimen or master plug, which was of no use to the maker, would have increased the first cost of the order considerably. And yet, a subsequent order for a plug damaged by wear or accident was to be filled accurately and without unnecessary cost.

Barring the dimension for the length of the plug, and the size and shape of the handle, as of no great importance, the essential dimensions for a plug are: 1. The diameter at the small end, and 2, the taper per foot or its equivalent.

Realizing that it is very difficult, if not impossible, to produce in the machine shop by measurement a piece representing accurately a given angle, I found that two straight edges touching two rolls of unequal diameter placed at a given center distance would represent a certain angle. Moreover, here are two elements which are easily produced with great accuracy. Every machinist knows that if he has scraped three straight edges together in such a manner that either one touches any of the other two for its whole length he can pronounce them absolutely straight. And again, the man handling a universal grinding machine will feel confident of producing a roll absolutely round and of a given diameter, even if the diameter is expressed in ten-thousandths of an inch.

Here then are the elements with which we can easily produce the angle represented by a given taper per foot. One difficulty

remains. We must arrange our elements in such a way that their combination will at the same time represent the diameter of the plug at the small end, and so excuse us from determining the same by actual measurement, which we could not do with any degree of accuracy.

Having ascertained the above facts in the machine shop, we proceed to lay out on the drawing board a diagram, like the one given in Fig. 3, page 165, and by the use of this diagram to solve our problem. We draw two circles representing two disks, whose radii are respectively R and r, with a center distance m. Against these disks we lay two straight edges, touching them as shown, a third one perpendicular to the line connecting the centers of these disks. The straight edges touching the disks are laid in such a manner that they also touch the third straight edge. It is now evident that an inclosure formed in this manner defines a taper, inasmuch as the taper per foot represented by the angle of the taper and the diameter at the small end are both given. The problem now is simply to find the diameter of two disks which, at a chosen center distance, will represent a given taper per foot, and under the above conditions of contact with three straight edges, will also define the given diameter of the plug at the small end. From the diagram, in Fig. 3, it is evident that in order to more easily solve this problem we must first find the angle a, which one side of the taper plug forms, with its axis or center line. A little consideration will show that this angle is expressed by
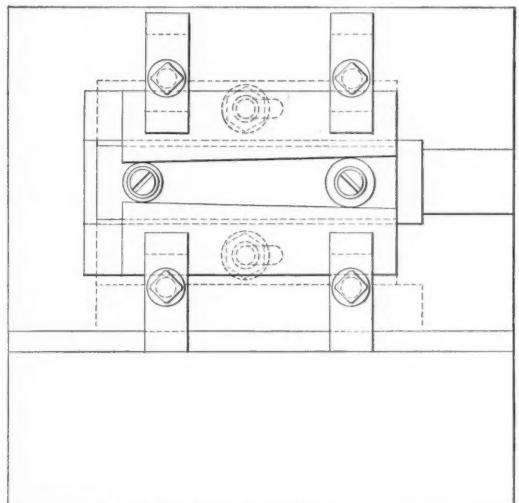

FIG. 2. FRONT ELEVATION AND SECTIONAL VIEW OF FIXTURE.

$$\tan a = \frac{\frac{1}{2} \text{ taper per foot in inches}}{12}$$

We assume a convenient center distance m for the disks, and have, therefore, the following known elements of our problem:
1. a = angle of taper with center line.
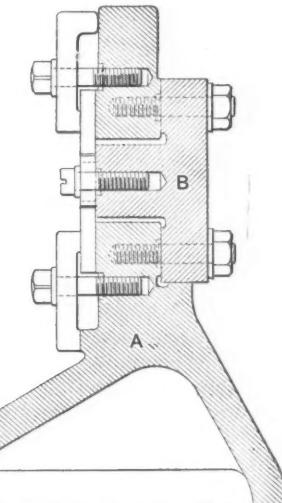
2. m = center distance of disks.
3. c = one-half of plug diameter at small end.

To be found are:

1. r = radius of small disk.
2. R = radius of large disk.

Turning again to the diagram, Fig. 3, we find:

$$\triangle\, B\, C\, F = \triangle\, D\, F\, C. \quad \text{Therefore}$$
$$c = d \quad (1)$$

From $\triangle\, A\, F\, B$ we find:

$$e = \frac{c}{\sin a} \quad (2)$$

From $\triangle\, A\, D\, C$ we find:

$$A\,D = e + d \text{ or (substituting (1) and (2)).}$$
$$A\,D = \frac{c}{\sin a} + c \quad \text{or}$$
$$D\,C = r$$

From $\triangle\, A\, D\, C$ we have:

$$r = A\,D \tan a, \text{ or}$$
$$r = \tan a \left(\frac{c}{\sin a} + c \right) \text{ or}$$
$$R = c \tan \left(\frac{1}{\sin a} + 1 \right) \quad \dots\dots\dots\dots\text{I.}$$

We further find that

$$R = s + r, \text{ and}$$
$$s = m \sin a$$
$$R = r + m \sin a \quad \dots\dots\dots\dots\text{II.}$$
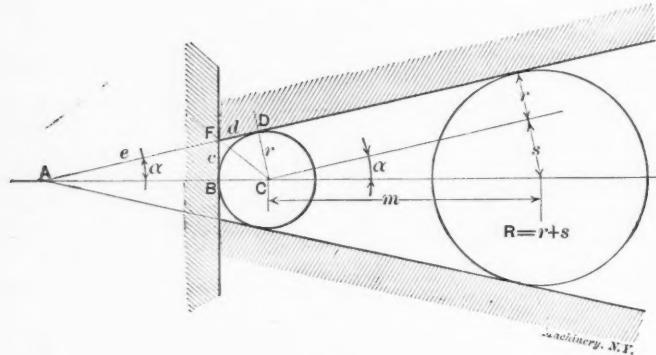

FIG. 3.

Having thus found the radii and, therefore also the diameters of the disks which will determine a given taper, we must make a fixture to put to practical use the information so gained.

Such a fixture is represented in Figs. 1 and 2. A cast iron body, A, Fig. 2, with scraped vertical surfaces on front and back, carries a block, B, which can be held to A by two screws going through slotted holes in B. This is to enable the workman to shift it horizontally. Block B carries two hardened and ground disks. Within certain limits the same center distance can be used, and therefore no provision is made to vary this dimension. As soon as the block B is in place with the disks for the particular taper to be produced, the straight edges are put in position and clamped. The vertical straight edge is not shown It is merely placed against the fixture to ascertain the correct location of the ends, the straight edge touching the disk and is then removed. Then block B is taken away, and the fixture, as represented in photograph, Fig. 1, is ready for use. In plac-and this fixture between himself and the light, the workman will have a convenient tool to which to fit a taper plug.

As will readily be seen, this fixture can be used for any taper within certain sizes, for which it was designed. Provided a record is kept of the center distance and the diameters of the rolls a certain taper can always be reproduced to given fixed dimensions. In actual use this statement has been fully verified.

THE PROBLEM REVERSED.

It is often desirable to ascertain the taper per foot of a given taper plug. For this purpose our fixture is admirably adopted. The plug we wish to measure is held against the fixture and the two straight edges are adjusted to touch it, and are then clamped fast. We now remove the plug and insert into the fixture a block similar to that in Fig. 1. This block carries two disks of known diameter. The only difference in the block now used to the one shown as B in Fig. 2 consists in the manner of hold-

ing the disks. In the former the disks are at a fixed center distance. This was found convenient for the former problem. In this case, however, the block has two slots through which the bolts holding the disks pass. The block having been placed in position, the disks are adjusted to touch the two straight edges and then clamped fast. The block is then removed, and the center distance of the disks is measured. We now have the following problem: "Given the diameters of two disks and their center distance, wanted the taper per foot of two straight edges touching them."

Consulting Fig. 4 and remembering that all values are expressed in inches, we find that the values for r, R and m are known. We further find that line x being at a distance of 12 inches from the intersection on the center line of a line parallel with one of the straight edges, represents one-half the taper per foot of the plug we are investigating. And, therefore $2x$ equals the taper per foot wanted, expressed in inches.

A mild dose of geometry and trigonometry will do the rest. We find:

$$\text{Sin } a = \frac{R - r}{m} \quad (1)$$
$$\frac{P}{12} = \sin a$$
$$\frac{P}{12} = \frac{R - r}{m} \text{ or}$$
$$P = \frac{12\,(R - r)}{m} \quad (2)$$
$$\frac{P}{X} = \cos a \quad (3)$$

By consulting our memory, or, in default of the same, a mathematical handbook, we find the following trigonometrical relation always exists:

$$\cos a = \sqrt{1 - \sin^2 a} \quad (4)$$

Substituting values of (1) and (3) in (4) we have:

$$\frac{P}{X} = \sqrt{1 - \left(\frac{R - r}{m} \right)^2} \text{ or}$$
$$P = X \sqrt{1 - \left(\frac{R - r}{m} \right)^2} \text{ or}$$
$$X = \frac{P}{\sqrt{1 - \left(\frac{R - r}{m} \right)^2}}$$
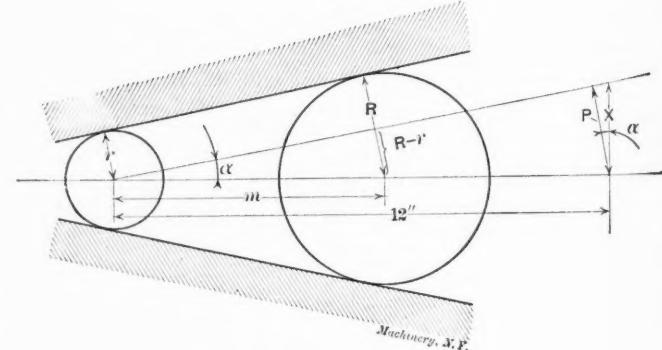

FIG. 4.

Substituting value of P from (3) we obtain:

$$X = \frac{12 \left(\dfrac{R - r}{m} \right)}{\sqrt{1 - \left(\dfrac{R - r}{m} \right)^2}}$$

Now for the sake of convenience, calling

$$\frac{R - r}{m} = D \quad \dots\dots\dots\dots\text{I.}$$

we can write

$$2\,X = \frac{24\,D}{\sqrt{1 - D^2}} \quad \dots\dots\dots\dots\text{II.}$$

Thus a simple solution of the problem is found.

TESTING INDICATOR SPRINGS.

A DESCRIPTION OF SEVERAL TYPES OF APPARATUS THAT HAVE BEEN USED FOR TESTING INDICATOR SPRINGS, BOTH IN THIS COUNTRY AND IN EUROPE.

Every mechanic or student of engineering is or should be interested in fine and accurate work wherever and whatever it may be. At the last meeting of the American Society of Mechanical Engineers, Prof. D. S. Jacobus read a paper telling of some work of this character that has been done at Stevens Institute, Hoboken, N. J., in testing steam engine indicators. It seems to be an appropriate time, therefore, to publish in connection with an extract from this paper a description of some of the methods that have been adopted elsewhere for testing indicators and their springs. Much of the apparatus used for this purpose is as interesting and instructive as any to be found in the whole range of scientific work.

In calculating the horse power of a steam engine, the mean effective pressure, obtained from the diagram, affects the results directly; that is, if the indicator be in error 2 per cent., the horse power of that cylinder will be in error 2 per cent. Where the difference in the consumption of steam of a small fraction of a pound per horse-power per hour may make the difference between a large bonus and a heavy forfeiture, as it sometimes does in installing a new engine, it is of the utmost importance that the part played by the indicator shall be as nearly right as it is possible to make it. At the best there is no assurance that the result obtained from the indicator will be nearer than two or three per cent. and with careless use of the instrument it may be much greater.

CHARLES T. PORTER'S METHOD.

When Mr. Charles T. Porter first began making the Richards steam-engine indicator in England, in 1863, he tested the accuracy of the springs by the simple, yet common sense method of loading them with weights. A flat metal plate was set on the work bench on which the spring was placed. A rod carrying the weight was put up through a hole in the bench and the plate and through the spring, with a nut on top, which had a bearing on the upper end of the spring. By adding or removing weights the spring could be tested through its whole range of action.

An indicator spring in actual use is never subjected to a temperature greatly exceeding 212 degrees, the temperature of saturated steam at atmospheric pressure, since that part of the cylinder which contains the spring is open to the atmosphere. Accordingly, to determine the effect of this temperature upon the action of the spring, Mr. Porter tested a number of springs cold, then allowed them to remain in boiling water for a few minutes and tested them again. He found the springs were invariably one pound in forty weaker when tested hot than when tested cold, a loss in strength of 2.5 per cent.

This, in brief, is the way in which the first indicator springs of the modern type were tested, and although the apparatus was of the simplest character, it was much to be preferred to many costly and intricate devices that have been made and used since the time when Mr. Porter began his work on the indicator.

PECULIARITIES OF SPRINGS.

In Fig. 1 is shown a Tabor indicator spring, which has two coils, one bearing on each side of the piston. Other springs are similar in appearance, although they all have their special features of construction. These springs are of various degrees of stiffness, to suit the pressure of the steam with which they are to be used. The degree of stiffness is called the "scale" of the spring, and is indicated by a number which shows the number of pounds pressure per square inch required to compress or extend the spring sufficiently to give the pencil one inch movement. Thus, a 40 spring requires 40 pounds pressure to move the pencil one inch. As shown by Mr. Porter, its elasticity changes with its temperature, and Prof. R. C. Carpenter states[*] that this variation occurs in a very irregular manner, and that between the temperature of 60 degrees and 220 degrees Fahrenheit the elasticity of the average indicator spring will vary about 3.5 per cent. That is, if the correct scale of a spring at 60 degrees temperature be 100, at 220 degrees it will require only $100 - 3.5 = 96.5$ pounds per sq. in. to move the pencil one inch. The elasticity of steel, also, may change with time

[*] In "Constants for Correcting Indicator Springs That Have Been Calibrated Cold." Trans. Am. Soc. M. E., Vol XV

and may or may not be the same at all loads within the elastic limit.

Aside from these qualities inherent in the steel, the construction and method of using the spring necessarily introduce irregularities. When an indicator is used on a non-condensing engine cylinder, the action upon the spring is wholly that of compression, but on a low pressure cylinder, where the pressure is partly below and partly above the atmospheric pressure, the indicator card must be traced in part by the extension of the spring due to atmospheric pressure, and in part by its compression due to steam pressure. During extension the diameter of the spring grows smaller, and during compression larger, and from this cause or from some other, its scale is invariably different under compression from what it is under extension.

In view of the foregoing considerations, and of the fact that there are sure to be errors in the indicator itself, due to friction, back lash, inertia and other causes, it will be seen how important it is to test indicator springs in place in the instrument, and as nearly as possible under actual working conditions.

FIG. I.

THE BROOKLYN NAVY YARD APPARATUS.
Upon which the Indicators are Standardized for Testing the Machinery in the Vessels of the United States Navy.

As far as we are able to determine, the first indicator testing device, in which there was an attempt to approach the conditions of actual practice, was made and used at the Brooklyn Navy Yard in 1888. The apparatus now in use there has been gradually evolved out of this first one, and is one of the most elaborate and probably the best-known apparatus for the purpose in existence. Through the courtesy of Chief Engineer W. A. Windsor, U. S. N., we were able to secure photographs of the apparatus, the illustrations from which will be of interest to those who have not seen it. The brief description which follows is made up from a paper upon indicator tests read before the American Society of Naval Engineers by Assistant Engineer F. H. Conant, supplemented by information concerning some of the later changes in the apparatus kindly furnished by Instrument Maker Charles A. Webb, who has immediate charge of the indicator testing room at the navy yard.

The apparatus consists primarily of a horizontal cylinder, technically styled a "manifold," into which steam at any pressure can be admitted or from which the air can be exhausted. The pressure in one case is accurately measured by a mercury pressure column, and in the other by a mercurial vacuum column. The indicators are attached to the manifold cylinder, and the pencil and drum mechanicisms are automatically operated at any pressure desired, by electrical contact with the mercury column.

The machine appears in Fig. 2, with Mr. Webb adjusting one of the indicators. The manifold cylinder, covered with lagging, appears at A. The mercury column is seen at the extreme right, and connection between it and the steam cylinder is through water pot E, in which the water is kept at a constant level by a steam trap. Steam is admitted to the cylinder through a valve at the right. On top of the horizontal steam cylinder are two horizontal shafts, the upper one of which is to operate the indicator drums and the lower one to apply the pencils of all the indicators simultaneously. It will not be necessary to describe these mechanisms in detail. By examining the illustration, however, it will be clearly seen that on the upper shaft there are pulleys around which the indicator cords pass, and that there is a handle at the end of the shaft for setting the drums. On the lower shaft are levers for operating the pencils with handles at the ends for setting the pencil mechanism. To operate the mechanism, the handle on the pencil shaft is raised, which draws the pencils about one-sixteenth of an inch away from the drums, where they are held by a detent fixed on the armature of a magnet. The handle of the drum shaft is then raised, which pulls the drums around a small fraction of a turn where they are held by a detent. The machine is now set. To trip it, electrical con-

nection is made with the magnet, which releases the pencil shaft and the pencils are drawn to the drums. This action of the pencil shaft at the same time releases the detent holding the drum shaft and the drums are moved back to their original position by their own springs, the pencils at the same time making a mark on the card about three-eighths of an inch long.

The electrical connection mentioned is made automatically

A test proceeds as follows: After the indicators have been carefully cleaned, oiled and adjusted and the pencil motion tested to see that it will fall, of its own weight, without the spring, they are put on the machine. When the steam comes through dry, the indicators are warmed up, and the cards put on. After setting the machine, the pressure in the large cylinder is reduced to two pounds below the atmosphere, for the purpose of pulling the piston down preparatory to beginning the up test. The cylinder is then opened to the atmosphere, and the up zero line drawn on the card. The cylinder is again closed and steam admitted to it in sufficient quantity to cause the mercury to rise in the column at the rate of about 2½ feet per minute. Lines are made at five or ten-pound intervals, according to the scale of the spring. When the limit of the test is reached, the pressure is carried one interval higher, and after shifting the drum shaft to bring the down lines into a new position, is allowed to fall, and the down lines are made, the cylinder being opened to make the down zero. In testing springs for pressure below the atmosphere, the test is commenced at the lower limit and lines are made at 2½-pound intervals.

FIG. 2. TESTING INDICATORS AT THE BROOKLYN NAVY YARD.

TEST CARDS AND THEIR IRREGULARITIES.

When three tests have been made a vertical line intersecting each set of horizontal lines is traced with the indicator. The indicator piston is then calipered when hot and the cards carefully measured. The accompanying illustration, Fig. 4, is a fac-simile of a test card. It will be noticed that there is a

through the mercury column at the instant the mercury reaches any desired pressure, and it will be understood if a brief explanation of the column be given. The column has a sliding joint at the base where it enters the well or pot of mercury, enabling the operator to raise or lower the whole column independently of the well, so as to bring the zero mark on the column to the correct zero level of the mercury, which changes with the atmospheric pressure. This adjustment is accomplished accurately through the help of two electrical contact points, one above and one below the zero level. They are connected by wires to two switches and a bell and battery. When the mercury comes in contact with either point it closes the circuit and if the switch be thrown in the bell will ring. To adjust the column for the zero point, therefore, it is simply necessary to adjust it so that the lower contact point will ring and the upper one will not ring when the switches are thrown in.

At correct distances on the column, above the zero point, are other contact points for heights of the mercury corresponding to every five pounds increase up to 50 pounds pressure, and every ten pounds increase between 50 and 250 pounds pressure. These are connected to a circular switch, which the operator can move so as to throw any one of them into circuit with the tripping magnet of the pencil shaft. When testing the indicators with the mercury in the column, a closed circuit must be used and a relay magnet is employed. As the mercury falls below one of the points, the relay releases.

For pressure below the atmosphere, communication with the main column is broken off by the valve at the bottom of the manifold cylinder, and opened to the vacuum column shown at the left of the illustration. In using this column the observer makes the electrical connection by a push button, when the vacuum reaches the desired point. The connection to the air pump is through a large chamber, having twelve times the capacity of the steam cylinder. Both pump and air chamber are shown in Fig. 3. The pump will produce a vacuum approaching the barometer reading within three-tenths of an inch, a remarkable performance due to extremely small clearance and a simple automatic device for operating the non-return valves. There are three cylinders, 4½x6 inches, and the pump runs at 70 revolutions.


FIG. 3. THE VACUUM PUMP AT THE BROOKLYN NAVY YARD.

difference in the positions of the up and down lines, which is due to friction or backlash in the indicator. Prof. Jacobus states that in using his apparatus, which will be described shortly,

he has found that with the instrument in correct adjustment and by taking precaution to keep its temperature uniform the up and down lines can be made to agree; but in ordinary tests this discrepancy is sure to exist to a greater or less extent. The practice at the navy yard is to take the mean of the up and down zero marks for the true zero, and to measure the distance of each line from this point. The mean error is then found for each pair of lines and if it is more than 2½ per cent. of the scale of spring at any point, the spring is rejected.
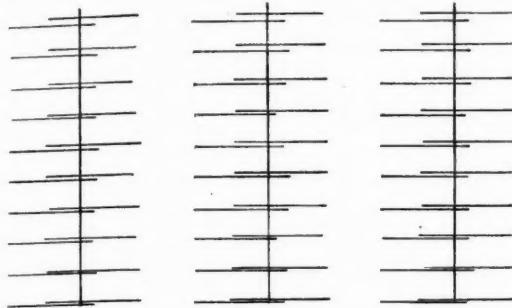

FIG. 4.

Another irregularity that is quite certain to be met with, although indicator makers try to avoid it, is that of an irregular scale—where the scale of the spring comes different at different pressures. A little thought will show this irregularity might cause a considerable error in obtaining the mean effective pressure from the diagram, and we have asked several engineers about their method of selecting a scale that would be fair to use in such a case. Prof. E. F. Miller, of Boston, replies: "If the spring is found to be out so that simply rerating will correct it, the spring is all right. That is to say, if a spring is marked 80 and is found to be out in such a way that it rates 80.2 or so, the spring may be used with the new rating. If the spring rates 80 at one place and 75 at another, the only thing to do is to condemn the spring, in my opinion. Most people expect too great accuracy in indicator work."

Mr. George H. Barrus, of Boston, writes: "When there is considerable variation at the different points, my practice is to take a sample card and calculate the error of the spring for the average of all the variations and then base the corrected scale on that. It is not so very much work to do this where it is to be applied to a steady or a fairly steady load, for, of course, in that case, it does not have to be done except for one card." Another well-known engineer who does not, however, wish to have his name used in this connection, says: "I think it is sufficiently accurate to get the scale of an indicator spring at an average point, as a general thing." At the navy yard they calculate the mean effective pressure of the card by using the nominal scale of
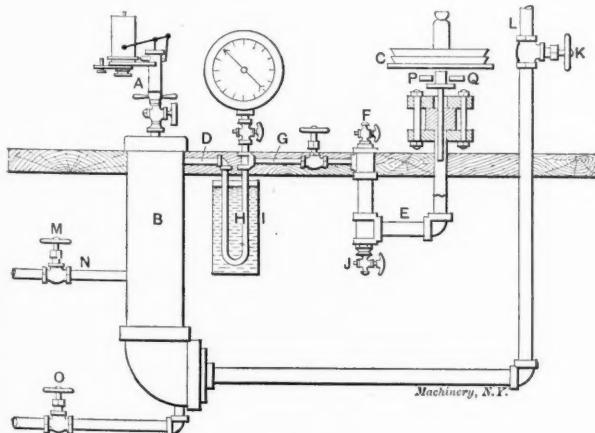

FIG. 5.

the spring and then correct the calculated mean effective pressure by taking in its stead the corresponding pressure obtained in calibrating the spring.

TESTING SPRINGS WITHOUT A MERCURY COLUMN.

Objections are sometimes raised to the use of the mercury column on machines for testing indicators, on the ground that the inertia and pulsation of the rising and falling mercury make it difficult to secure coincident up and down lines on the dia-

gram. The apparatus used by Prof. Jacobus and described by him at the last meeting of the American Society of Mechanical Engineers registers the pressures without a mercury column. They are illustrated in Figs. 5 and 6, the one in Fig. 5 being used at ordinary pressure. The indicator is placed at A on top of the cylinder B, which is made of a piece of six-inch pipe, about two feet long. The pressure is measured by means of a plug and weight device, C, which is spun around so as to eliminate the effect of friction. The U-shaped pipe E is filled with oil. Before starting to calibrate the indicator the pet cock F is opened slightly, to allow any air in the pipe G and the siphon H to escape. This siphon H is surrounded by water contained in the vessel I, which condenses the steam entering it through the pipe D, so that when all the air present is allowed to escape through the pet cock F, the pipe G and the siphon H will be filled with water. The pressure is adjusted by regulating the valve K in the supply pipe L, which furnishes steam, water, or compressed air to the apparatus, and also by adjusting the valve M in the escape pipe N. The pan of the plug and weight device C is limited in its movement by means of a fork, which comes in contact with it only when the pan is in the extreme positions; the two prongs of this fork are shown in section at P and Q. The readings of the gauge are not used in testing the indicator, but as general guide in the use of the apparatus. The diameter of the plug in the plug and weight device C is 0.5 inch, and the hole in the bushing, 0.5005 inch. Both the plug and bushing are ground true. The average area of the plug and of the hole in the bushing is used in calculating the weight required for a given pressure.

In testing indicators with steam pressure, the steam is brought to the maximum pressure to which the indicator is to be sub-
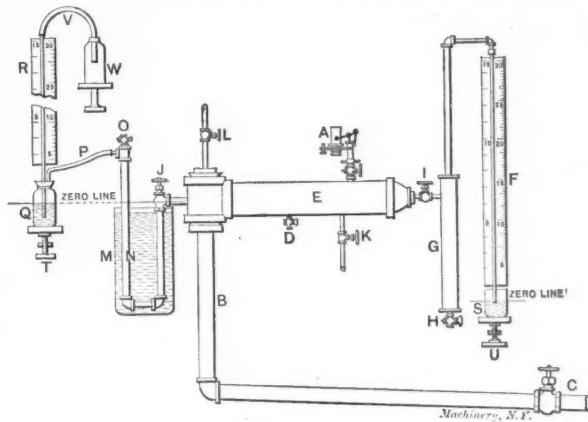

FIG. 6.

jected; the indicator cock is then opened and closed quickly a number of times, in order to heat the indicator. The steam is then released from the cylinder B, and the atmospheric line is taken after turning the indicator cock to the proper position. In taking the atmospheric line, as well as the lines for any other pressure, the pointer of the indicator is first pressed upward, and then released and a line taken, then pressed downward and released and a line taken, the indicator being rapped sharply with a small wooden stick before taking each line. After obtaining the atmospheric line, steam is admitted through the valve K, until the pan and weight device is balanced while being rotated. This requires a very fine adjustment, and the line is not taken until there is no tendency for the plug and weight device to either rise or fall.

The apparatus employed in testing springs used under a vacuum is shown in Fig. 6. The indicator is attached at A to the top of the horizontal cylinder E. The pipe B leads to a vacuum chamber and pump, and slopes downward, so that no water can collect in it. The amount of vacuum is regulated by adjusting the valve C, leading to the air pump, and by admitting a small amount of air through the pet cock D. The vacuum gauge at F is graduated in inches of mercury and in pounds per square inch. G is a chamber for condensing any steam which may pass through the valve I, and thus prevent it from condensing on top of the mercury in the gauge F. The height of the mercury cup S is adjusted by means of the screw U, so that the surface of the mercury is on the same level as the zero point of the scale.

The apparatus may also be used for testing springs at pressures up to fifteen pounds above the atmosphere, the mercury column R being used for this purpose. Where a spring is used for both a slight pressure and a vacuum, the entire calibration can, therefore, be made with the apparatus shown in Fig. 6.

A METHOD OF TESTING INDICATORS WHEN RUNNING UNDER ACTUAL WORKING CONDITIONS.

Thus far the apparatus described has been for static pressure only. A machine has been designed,* however, by Profs. Peabody and Miller, of the Massachusetts Institute of Technology, Boston, for testing the scale of a spring under steam pressure, while the indicator pencil is tracing a diagram similar to those taken from a steam engine. The apparatus can be run at any desired speed, so that the inertia effects of the piston, spring and pencil levers may be made to approach as closely as possible to the conditions of practice.

The essential part of the apparatus consists of a cylinder casting shown in vertical section in Fig. 7, and in horizontal section in Fig. 8, and which takes the place of a regular steam-engine cylinder in conducting the tests. What may be considered as the cylinder proper is the chamber A above the horizontal division wall. The indicator is attached at I in the usual manner. There is no piston in the cylinder A and the object to be accomplished is to alternately admit steam to the cylinder and exhaust it from it, at the same time giving the indicator drum a motion so that a card may be traced.

The admission of the steam is controlled by the upper end of the slide valve V, which is operated by an eccentric. Steam passes from the valve chest C by the upper end of the valve into the cylinder A, and then exhausts under the slide valve to the lower chamber B.

One of the cards taken is shown in Fig. 9. Admission occurs at the right end of the card, the pencil rises to above its normal position, then sinks below it and finally traces a straight line, while during exhaust there is a similar action in the reverse order.

Provision is made for changing the upper and lower pressures of the steam, so that cards may be taken under a variety of conditions; and also for comparing these pressures, as indicated on the cards with the actual pressures of the steam, as determined by the mercury column.

The last is accomplished through two piston valves, which, like the slide valve, are actuated by eccentrics, and which operate in the valve chambers, P, P, Fig. 8. The purpose of these valves is to connect the chamber A alternately with a mercury pressure column and a vacuum column at the periods of admission and exhaust so that the two extreme pressures of the diagram may be accurately measured. A section of one of the valve chambers with the valve in place appears in Fig. 10. Steam from the cylinder enters an annular passage around the valve at a; goes through a hole, b, into the inside of the valve, which is hollow; passes down and out through a hole, c; and finally from the passage d the steam is piped to a horizontal steam pipe four inches in diameter and thirty-six inches long, which is kept exactly half full of water, and from the water a pipe leads to the mercury column. The two valves are identical in every respect, except that one opens after the slide valve is fully open and closes before the slide valve begins to shut its port, while the other opens after the exhaust from the cylinder begins and closes before exhaust ceases.

In Fig. 11 is an outline drawing of the machine. The uprights R, R, are pieces of large pipe, serving both as frame for the machine and as supply and exhaust reservoirs. The upper and lower steam pressures are controlled by valves. The drum motion is taken from one of the eccentrics.

A GROUP OF CONTINENTAL MACHINES.

For the purpose of illustrating recent European methods of testing indicator springs, several engravings of apparatus de-

* Described in the Transactions of the Society of Naval Architects and Marine Engineers, for 1894.

signed and used abroad are shown on page 171. They are reproduced from the proceedings of "Les Ingenieurs en Chef des Associations de Proprietaires d'Appareils a Vapeur," sessions of 1894 and 1896, held in Paris. A peculiarity of these apparatus is that none of them test the indicator under steam pressure, the condition in actual use, and yet there is an evident attempt to supply in a measure the conditions of practice.

In Fig. 12 is a detail sketch of an elaborate and an expensive device designed for weighing the elasticity of the indicator spring by the application of weights to one end of a scale beam. A brief study of the sketch will show that all the details have been worked out with the greatest care. The machine rests upon a base (not shown), having leveling screws, and a plumb bob is suspended from point A to assist in bringing the base into a level position. The indicator is attached at I and the weighing lever L with fulcrum at F compresses the spring through the spindle S, which bears at the center of the under side of the indicator piston. The weighing is done by standard weights placed upon the scale pan P and the reading of the vernier at the extreme right end of the beam shows the deflection

SECTION X-Y.   FIG.8

SECTION Z-Z
FIG.10

FIG 9

FIG.7

12"TIGHT AND LOOSE
PULLEYS. 3"FACE.

2"PIPE.

FIG.11
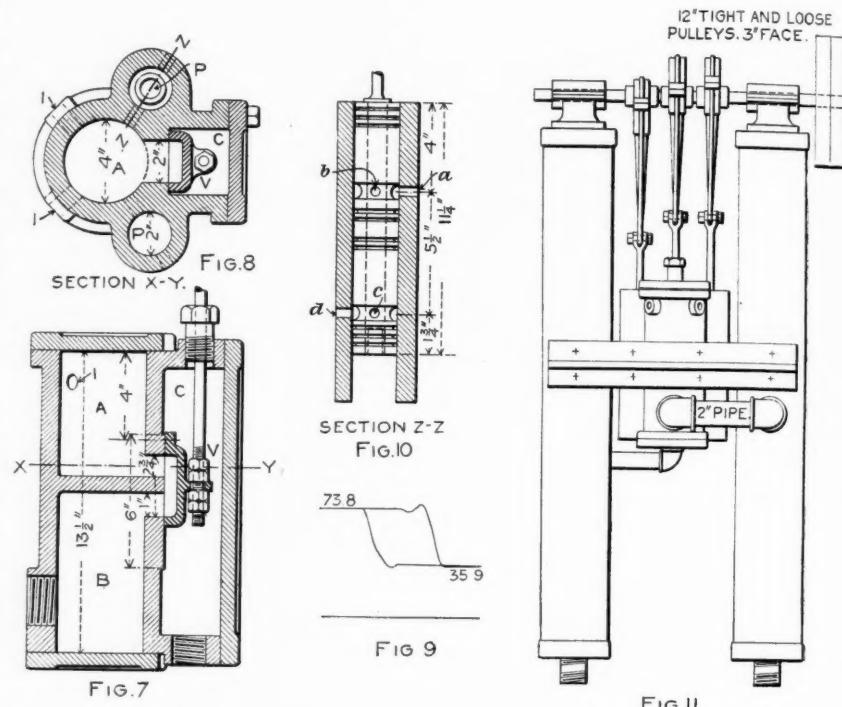
of the spring. In testing different indicators allowance must be made for the different diameters of piston since the total steam pressure on a large piston is greater than on a small one. The knife edge bearing the weight pan is therefore arranged to move along the beam and has a vernier for accurate adjustment. Counterpoise weights are provided, the lower one, W, being partly to keep the spindle S in an upright position. With the indicator placed at K and by attaching weight rod T to the lower end of the indicator spindle, the spring can be tested in tension. A pipe, V, is a steam connection for heating the indicator and spring to the temperature of 212 degrees.

The criticism that will doubtless be made upon this machine is that in testing a spring for compression any movement of the lever L will produce an angularity in the spindle S, tending to press the indicator piston against the side of its cylinder, producing increased friction. To prevent this result the spindle is made to screw into or out of the block M by turning the handle H. When the scale beam is deflected by placing a weight on the weight pan, the spindle S is lengthened by screwing it out of the block until the beam is brought back to the zero mark, when another weight is added and the process repeated.

In Figs. 13, 14 and 15 are apparatus designed under the direction of MM. Walthem-Meunier, Ludwig and Weber. That in Fig. 13 is somewhat of a curiosity. The curious feature is the roundabout method for heating the indicator by a blast of hot air. The blast is furnished by a hand-driven blower at B, which drives the air through the pipe coil C, heated by a gas flame un-

A COLLECTION OF INDICATOR TESTING APPARATUS FROM EUROPEAN SOURCES.

Fig. 12

Fig. 13

Fig. 14

Fig. 15
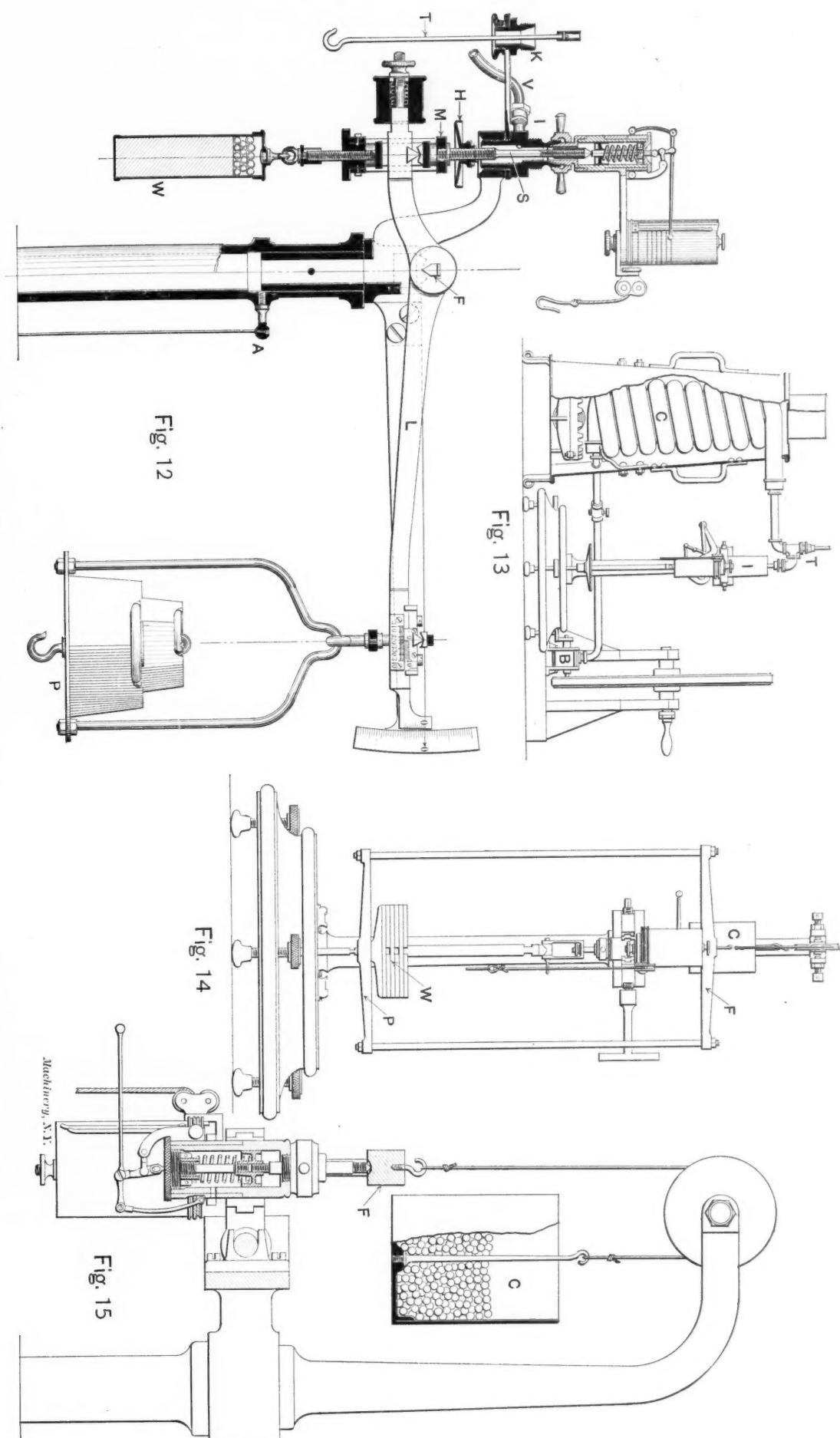
derneath. The hot air enters the indicator at I and its temperature is taken by a thermometer at T.

It is difficult to see why one should make an apparatus of this sort when it is so much easier and better to test an indicator by the direct pressure of steam upon the piston. In the first place, the water that inevitably blows through an indicator pipe with the steam assists in the lubrication of the piston, a condition which heated air cannot establish; and in the next place the temperature of an indicator cylinder and an indicator spring is not the same in actual use. The cylinder is heated to the temperature of the steam in the engine cylinder, while the spring, which is exposed only to steam at or nearly atmospheric pressure, is at a temperature not far from 212 degrees. Some good engineers believe that friction is dependent to a certain extent upon temperature, and the systems of heating of Figs. 12 and 13 are defective in that both spring and cylinder are brought to the same temperature.

Figs. 14 and 15 illustrate the same apparatus, in one case the spring being tested for extension and in Fig. 15 for compression. This apparatus is much simpler than that of Fig 12, and has the advantage of exerting a direct pull upon the spring without the intervention of levers. A framework, F, carries a weight pan, P, bearing the weights W, which measure the strength of the spring. C is a counterpoise for balancing the frame F. With the indicator in an upright position, as in Fig. 14, the weights are made to pull upon the spring, while with the indicator in an inverted position the upper bar of the frame can be made to push down upon the spring. Apparently not so good a feature of this apparatus is the method of holding the indicator while under test. It is clamped by the outside of the cylinder, and unless this is carefully done, there might be serious danger of distorting it. L. G. F.

* * *

HOME MADE BROACHING RIGS.

The general idea of a rig for broaching holes is shown in Fig. 1. I do not remember in what shop I saw this, but it occurs to me in connection with some other devices for the purpose that I shall describe. It consists of a strong casting bolted to the end of a planer for the work to rest against, and a fixture, c, securely fastened to the platen, with a spring latch to catch the small end of the broach automatically and draw it through the work. The small ends of the broaches are made so as to slip through the rough hole to be broached, and project far enough to be caught and drawn through by C; when they are readily slipped out and immersed in oil or soda water, to clean and lubricate them, in time for the next stroke.
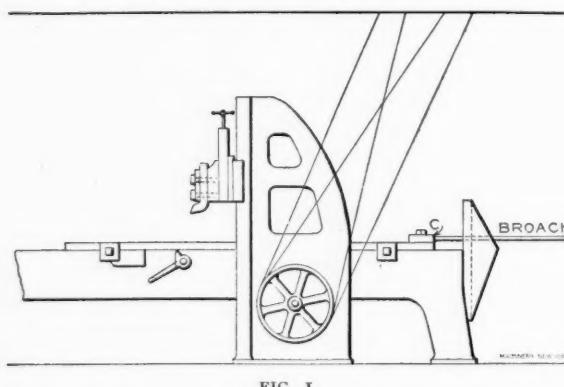

FIG. 1.

With a suitable speed there seems to be no reason why quite a variety of work could not be done with a rig of this kind. I found it in one of the smaller shops in Worcester, Mass., where the holes through the movable jaws of small monkey wrenches were being finished in a very rapid and satisfactory manner by it.

A large broach, drawn through by a powerful screw-driven device, is used in making the Prentis vises, and I think the largest size of hole is about 3x6 inches. It was a pleasure to witness the operation, and I shall never forget that the Prentiss vise is one that is put together as it should be. More than once in my shop experience I have felt obliged to leave my own vise to use that of a shop mate. Invariably I would seek a Prentiss.

By drawing, instead of pressing, broaches through the work, it is possible to use long, slender broaches, and they have a greater tendency to center themselves, and work better generally.

I remember seeing some very interesting object lessons in this kind of work at John T. Burr & Sons, Brooklyn, N. Y., who build key-seating machinery on this principle.

At the Johnston Harvester Co., Batavia, N. Y., I found what appeared to be an old home-made machine for key-seating pulleys, etc., that worked by rack and pinion similar to a planer.


CUTTER BAR END VIEW
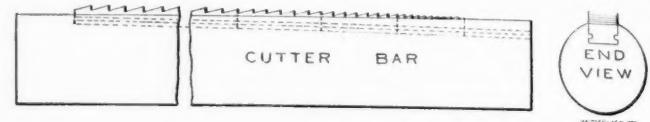
FIG. 2.

The cutter bar was made on the plan shown in Fig. 2, with the cutter in interchangeable sections, about 6 inches long. In this case the cutter bar was comparatively stiff, and secured rigidly in its holder, which worked back and forth through the bushing like the ram of a shaper, making the key seat at one stroke. One end, Y, of each bushing is made the same and fits the machine, while the other end, W, varies according to the size of the hole

WORK. KEY WAY. CUTTER BAR. Y W BUSHING. MACHINE.
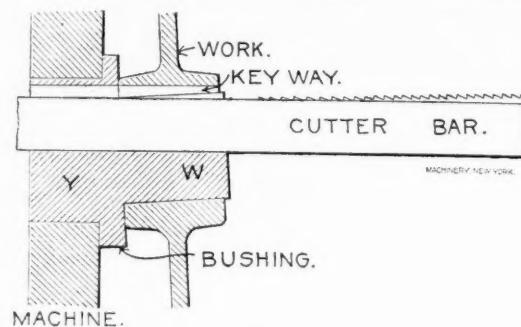
FIG. 3.

to be key seated. In the case of taper keys, W is tipped enough to suit the taper, as shown in Fig. 3. In operation, the pulley to be key seated is slipped on over the cutter bar and up against W until the cutter bar is out to the limit of motion, which permits the work to slip on over it, as shown, ready for the cut. A. L. G.

* * *

QUARTER TURN BELTS,

Quarter-turn belts are always held up as horrible examples of all that is bad in mechanical construction, and it does not require a very extended experience with them to convince one that they are about as black as they are painted. In a recent issue of the "Woodworker," it is pointed out by a contributor, Robert S. Brown, that the trouble lies in the fact, indicated in the illustration, that as the belt leaves the upper pulley one side, A, is loose and usually ruffled, as shown. All the work of driving them comes on side B, which will be strained and stretched. The same thing occurs where the belt leaves the lower pulley, and this stretching soon gets the belt out of shape—stretched all along on one side, with driving power diminished, and it is apt to run off the pulleys. Cutting the belt on a radius with outside edge of curve, i. e., the long edge run on side of pulleys where stretching usually takes place, helps some, but is decidedly objectionable in that it requires a belt to be made especially for each piece used.

As a way out of all this trouble, Mr. Brown suggests the arrangement shown, which consists in lacing the ordinary straight belt with one of the joining ends, having the flesh side out and the other with the hair side out. It will be noticed that this does not twist the belt between the pulleys more than the common arrangement; for what was a quarter twist one way becomes a quarter twist in the other direction when the belt end is turned half way around. Then, as the belt travels, point B on the right side appears at A after passing around once. The point gained is the equal stretching of both sides of the belt.
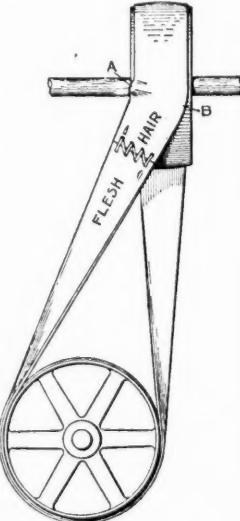
MOLDS.—2.

METAL MOLDS—MOLDING BY PRESSURE—OTHER OPERATIONS THAT COME UNDER THE HEAD OF MOLDING—MOLD MAKING.

WARREN E. WILLIS.

Perhaps no better example of the nicety of mold making occurs, nor one in which want of accuracy would be more widely noticeable, than that for metal type; whether it be for single characters, or, as in such machines as the "Linotype," where whole lines are produced by one operation.

A little reflection will show that the body of each character must be as absolutely parallel as it is possible to make it; that its face must not only be square with its body, but that its position as to height and distance from the edges of the type must be duplicated in every piece. Clean sharp outlines and solid bodies can be obtained only by the method which, up to a compara-

made in one casting. Holes may be "cored" as small as can be drilled, and with no perceptible "draft;" saw cuts can be duplicated as narrow as desired, and the cut warranted not to "run off."

In fact, the imitation of the model is all that can be desired, and as the loss in casting is practically nothing, there seems to be no reason why this form of mold casting should not become as popular and extensive or even more so than drop forging.

The manufacturers of mechanisms for displaying, indicating, registering and vending, who have made use of the combinations of aluminum, tin, zinc, copper, nickel, lead, antimony and the like, are well able to appreciate the advantages of improved methods in mold casting and are also aware that certain alloys of these metals possess a range of strength and hardness that makes their use possible, except in pieces subject to percussion or sudden and violent strains, such as would ordinarily necessitate the use of steel.


FIG. 2.

FIG. 3.

SAMPLES OF CASTINGS MADE UNDER PRESSURE IN METAL MOLDS.

tively short time ago, was used in type foundries alone; i. e., casting under pressure.

Metal molds are used, of course, and are kept at what is commonly called "sissing" hot. While the parts forming the bodies of the type are frequently renewed, the faces seldom are, since the original faces are used for the purpose of electrotyping only, and the copper shell thus obtained for the matrix or mold for every-day work.

The making of the original possesses much interest and is proceeded with about as follows: Each character having the distinguishing characteristics of its particular font is first drawn carefully upon paper to a scale of about 200 to 1, or from 12 to 15 inches square.

When the set is complete they are transferred to thin brass or steel plates, sometimes of the same size, but more frequently smaller—usually about one-half. These plates are very carefully cut on the lines and used as guides or formers in a style of pantograph machine, which reduces to the required size on a blank by means of exquisitely fine revolving cutters, leaving only the sharp internal corners to be touched up by an expert engraver.

Very similar to the manufacture of type is the process of casting in metal molds which has lately received much attention and is the subject of several patents. These patents cover the arrangement of molds in connection with the melting pot, the specifications showing the inventors' (?) appreciation of the importance of having the whole operation carried on so as to lose as little heat as possible in the conveyance of the melted metal from the melting pot to the mold, and also the desirability of having a uniform amount of pressure on the molten metal until it shall have set.

As in drop forging, the cost lies largely in the dies and quantity of pieces to be made and also their use; the dies, however, are far less bulky than in drop forging, consequently lighter and less expensive, and are not subject to such severe use, and therefore last longer.

In Figs. 2 and 3 are shown several pieces, the largest one of which is part of a Berliner Gramaphone, and has a fairly accurate thread, shaped by the mold, and the piece is so well formed that no machine work is done either upon the thread or upon the seat at the end of the thread, against which the diaphram is clamped. Besides threads, various lugs, projections and lettering appear, clean, sharp and distinct, with smooth surfaces, and in most cases ready for assembling. Expensive pieces, formerly made up of several distinctly separate parts, can by this process be

Another step, perhaps somewhat in advance of the times, and delayed by reason of the double expense incurred, is that of coining after casting; the combination imparts the exact finish of the dies, increases density and strength and produces entire uniformity. When applied to selected alloys, wire brushing between the operations of casting and coining will produce results far superior to any present method of machining. The better class of
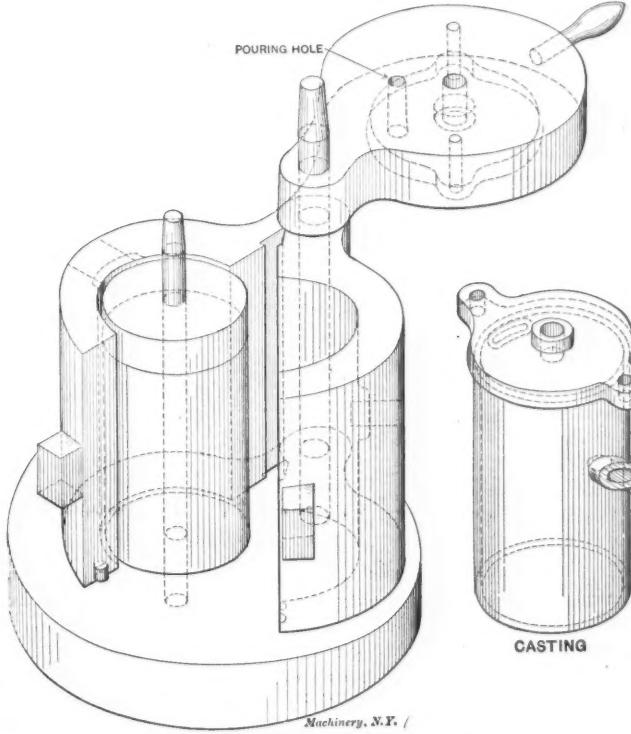
FIG. 4.   A COMMON FORM OF MOLD.

drawing instruments are made by this method, which, while not new, is comparatively unknown.

The common style of molds used in factories, where they do not make a specialty of such work, is fairly represented in Fig. 4, which illustrates a mold for casting a cylinder, closed at one end and open at the other. A hole is cored through the solid end in its center, another through the side midway its length, and opposite to this is an oblong rectangular opening, with

rounded corners, near the closed end of the cylinder, forming a port. Around the closed end runs a bead, enlarging on two opposite sides into lugs, by which the cylinder is attached to its supporting frame.

This particular case shows the mold to be made of four main parts: (1) The base, having the large projections which form the interior of the cylinder, and which also support the post shown in the figure; (2) the sides, which are arranged to swing away from the casting as soon as it has been cast; (3) the cover, which shapes the top of the article, and (4) the rod which passes loosely through the base and has at its upper end a disk the size of the inner diameter of the cylinder and which can be made to raise the casting from the mold by forcing the rod up from below. The upper part of the rod forms the hole in the head of the cylinder, and is released from it by slightly jarring it while held in a reversed position.

A pin is provided so that in closing the sides of the mold together they will be located equally distant from the center, and projections on the sides provide means for clamping them while pouring through the top. Various holes and projections, lettering, o r n a - mentation, etc., may be added to the sides and faithfully re-produced in the article.

In molds made for ordinary poured work, attention must be paid to having vents of suffi-cient size properly located; this is often a matter that is neg-lected, and the consequent trouble charged to causes other than the entrained air, which forms "pockets" or "blows" in making its escape.

FIG. 5.

Metal molds are customarily covered on their interior sur-faces with chalk, or held over a flame to receive a deposit of soot; either one, being a good non-conductor of heat, materially assists in preventing the molten metal from becoming chilled too rapidly by contact with the naked walls of the mold.

The temperature of the metal is highly important, but as the fluidity varies with the alloy employed, it is a subject of experi-ment with each mixture; if too hot, loss is incurred in the ma-terial, and if too cold, imperfect castings result. Covering the surface with powdered charcoal helps to prevent oxidation, and also loss of heat by radiation.

In pouring babbitt bearings the average machinist knows that a cold arbor and lots of putty produce an uneven and mottled surface, having the appearance of broken bubbles—which they are—and that a hot arbor covered, when practicable, with a film of anything but cold metal, and having upon it a few mere scratches, provided they are not filled up, produces comparative-ly smooth surfaces.

Molds for Other Purposes.

Any form of mold casting is but an amplification of the pro-cess of babbiting a bearing, the essential details being the same as in the simple operation of "running a box."

Wire rolling is an adaptation in which the mold is of an in-finite length; forms for special purposes are readily produced at an expense that compares very favorably with drawing, and has the distinct advantage that it may have depressed or embossed corrugations, threads, marks and small figures readily applied during the process. A neat way of forming letters that are to appear at regular intervals on the work, and which may be ap-plied to otherwise finished rolls, is by etching with acids in the usual manner.

On the same plan as wire rolling is the more refined "Ecau-bert" system of dies, which are circular, internal molds, made in two or more parts, engraved with ornamental devices; into these the work, of somewhat smaller diameter, is pressed, both work and die revolving, after the manner of metal spinning.

When the work has been forced against the dies sufficiently to have received their shape—in reverse—the dies are opened into their several sections and the work is removed; many circular

pieces having the appearance of being engraved are done in this manner, as, for instance, those parts of a watch case known to the trade as crown, bezel and centers.

In the case of rolling, the operations are performed continu-ously and the metal is usually cold; in all cases it is compressed and at the same time stretched, no loss being entailed. If much change of form is desired or reduction of section area, it may be-come necessary to anneal the work one or more times to keep it in condition for further working; if allowed to become hard enough to show much "springiness" it will be so brittle that breakages are apt to occur and unsatisfactory work result. The most desirable way to anneal appears to be by having the work pass from a gas furnace, kept at the proper temperature, through a cooling medium, to the rolls direct.

Mold Making.

The numerous and profitable uses to which dies are put and which have been but alluded to here, have brought about a dis-tinct subdivision of specialists in mechanics, known as die, or mold makers.

Men who are skilled at this occupation realize the necessity of a full, clear and complete conception of what the article will look like when formed; without this, waste of time or material, and probably both, will result. A model or drawing, with any needed explanations, are necessary preliminaries.

In molds used in forging and pressure casting, the steel for the dies should be high in tensile strength, but not neces-sarily as high in carbon as for a cutting tool; American steel is as good to make American tools from as any im-ported steel. No doubt the reverse was once the case, but is so no longer. It is to be preferred, not on account of its nationality, but because of its price, for equal quali-ties, and the fact that most manufacturers and many dealers keep in stock blocks of special temper and of various sizes for these purposes. The shape and size is governed in each case by attendant conditions, and all that can be said in a general way is not to be stingy with stock.

Ways and means for securing the dies are first considerations. The dies must be secured beyond a reasonable doubt, and pre-caution in this respect is the "ounce of prevention." Any move-ment from the original alignment is exceedingly dangerous, if not disastrous. The construction of the press or mold holder de-termines the manner by which the dies shall be held; the fasten-ing should be such as to admit of interchangeability, and it should hold with rigidity and security against accidental movement.

The common form of press for ordinary mechanical drop press work has been shown, while for lighter work, such as, for in-stance, jewelry, the prevailing force seems to be that of several heavy screws pointing toward a common center, at an angle
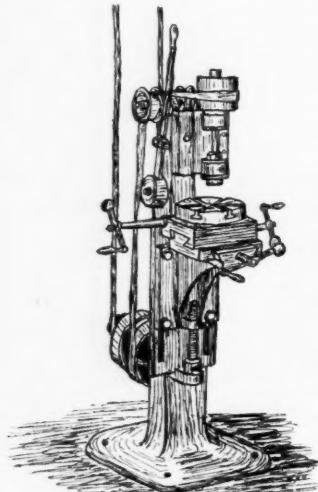
FIG. 6.   A DIFFICULT PIECE.

downward, the points converging at the conical or wedge shaped sides of a rectangular based die. These screws, which, with the blocks in which they are held, are called "poppets," are set and held from loosening by check nuts, affording a safe and secure fastening, at the same time admitting of ready adjustment in any required direction.

Dies cost in proportion to the accuracy demanded, other things being equal; the item of labor being the more important factor. Improvements in cheapening and increasing the efficiency of die making tools have been marked during the last few decades, and the results are becoming apparent. The drill, chisel and file have largely given way to the die sinking machine, which usual-ly takes the form of a vertical spindle milling machine, whose

table may have cross, transverse, vertical and rotary motion, and whose spindle is adapted to use a large variety of cutters, having more or less accurate means of end adjustment.

The typical illustration, Fig. 5, shows how these movements are commonly arranged, although in some cases means are provided so the operator can duplicate another die, used as a former, by another spindle, on the profiler or edging machine plan. One ambitious maker constructs his machine with the cutter below the work table, having a pointer indicate the center of the spindle and the design laid out to correspond with this reversed order of things.

Dies used for work where the depression is comparatively slight are cheaply and advantageously made by the process known as "striking up," with what is technically termed a force. The said "force" is a piece of steel bearing the design upon its business end, precisely as it is to appear upon the finished article; when completed and hardened it is "forced" into the die—which has previously been made sufficiently soft by heating—by a blow, either from a light press or hand hammer; the "force" being held in the proper relation and squarely to the die by any convenient means. Should one blow be insufficient, the scale is carefully removed from the face of the die, which is reheated and the operation again gone through with.

It is evident that duplicate dies can be readily produced at a cost but little exceeding the material. Several years ago a similar experiment was tried, on a larger scale, of making dies by the use of a cast-iron "force" dropping upon the prepared blank from a considerable height, say, from 60 to 100 feet. The feasibility of the plan seemed to have been demonstrated, but for some cause unknown it does not appear to have been commercially successful. The constantly increasing demand may lead to experiments in this or other directions, and evolve something practical and less expensive than cutting out stock.

The illustration, Fig. 6, is of a piece considered rather more difficult than ordinary, and is a fair example of what can be done.

* * *

STARTING AND STOPPING A BOILER TEST.

In the January proceedings of the Engineers' Club of Philadelphia, Prof. Henry W. Spangler has an extended paper upon Engine and Boiler Testing. In approaching the subject of starting and stopping a boiler test he states that he considers the practice of drawing the fire at the start and finish as simply barbarous, and with the other standard method, where the condition of the fire at the beginning and the close is judged and the difference allowed, the economy must inevitably be greater, the greater the allowance. He prefers a third method, which has been used for some years, and which he considers fair to both boiler and prospective owners. It is much more tiring on the engineer conducting the test; but that he can charge for, if he pleases. The scheme is this: Suppose we have a 100 H.P. boiler to test for capacity, test to run from 8 A. M. to 6 P. M. The coal is such that the fires are to be cleaned twice in the test. Fire should be on the boiler twenty-four hours before the test begins. Beginning at 2 A. M., the boiler should be fired at about its capacity. Roughly, 400 pounds of coal should be burned each hour from 2 A. M. until 7 A. M. It is not necessary that any account should be taken of water, nor any other data for test purposes. All we want is heavy, dirty fires at 7 A. M. At 6.30 the water level is brought to the point at which it is to be carried, and is kept there, and all conditions brought to running conditions. At 7 begin cleaning fires. Put, say, 400 pounds of coal on the floor and allow the fireman to use it to the best advantage. Note the time he begins using the next lot of coal. Say this is 8 A. M. This is the time at which the test really begins. At 5 P. M. clean fires again and weigh out 400 pounds of coal, the same amount as in the morning. See that it is all used up by 6 P. M., when the test ends. The fire at the end of the test will then be as nearly in the same condition as at the beginning of the test as it is possible to make it, barring the fatigue of the fireman.

This seems more intricate than the standard methods, but neither the boiler nor the results can be jockeyed.

* * *

It is reported that a successful long-distance telephone test has been made between Little Rock, Ark., and Boston, Mass., a distance of 1,900 miles.

SHOP TALKS WITH YOUNG MECHANICS—11.

MANDRELS.
W. H. Van Dervoort.

The term mandrel is applied to that class of tools upon which work that is to be machined between centers is usually held. It is frequently called an arbor, although the distinction between the two may be quite clearly defined. A mandrel is designed to carry work that is to be operated upon by a cutting tool, while on the other hand the arbor carries and drives a cutting tool, as with the milling machine and saw arbors.

Mandrels may be classed under two heads, solid and expanding. The solid mandrel is made slightly tapering, in order that it may be forced to a tight fit in the bore of the work. The amount of this taper varies with the class of work the mandrel is to be used on, it being but slight at the most.
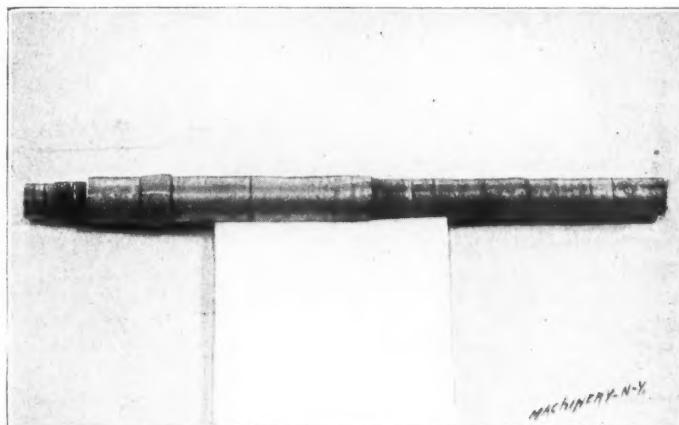

FIG. 185.

A bar of common round iron or steel centered and turned to the required diameter constitutes the mandrel in its simplest form. Such a tool, as it is usually found in the average jobbing shop, is shown in Fig. 185. It is hardly worthy the name mandrel, although a solid one might fairly come under the expanding, or rather shrinking class, as it is brought down by turning and filing to fit the bore of every new piece of work that comes along. It has one quality, however, that can always be depended upon, and that is untruth. With mandrels of this class accurate results cannot be expected.

Since a mandrel must be rigid, it should be as short as the nature of the work will permit, and made of as stiff a material as possible. Its centers should be carefully formed, and the
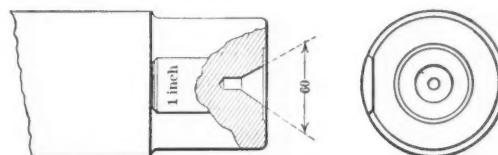
Fig. 186.

Fig. 187.

body finished cylindrically true upon them. The centers, at least, should be tempered or case hardened, to prevent their wearing out of true. In Fig. 186 is shown the correct construction for the end of a mandrel. The end for a length about equal to the diameter of the tool is reduced slightly in diameter and provided with a flat on one side, against which the screw of the dog or driver is set. As the dog is very apt to mutilate somewhat the ends, this reduction in diameter is quite necessary. Since the accuracy of the mandrel depends so much on its centers, it is necessary to protect them as much as possible from injury while forcing the mandrel into the bore of the work. This is best accomplished by recessing the ends around the center bearing as shown in the figure. The angle of the bearing should be 60 degrees, with a small hole drilled at the

bottom. The object of this drilled hole is to prevent strain being thrown onto the delicate point of the machine center, and to form a small oil reservoir to aid in lubricating the bearing.

In Fig. 187 is shown a hardened and ground steel mandrel. These tools are made for general shop work, the length increasing with the diameter from 3¼ inches for a ¼-inch mandrel to 17 inches for a 4-inch. These lengths are, of course, arbitrary and may for special uses be materially increased or decreased. As manufactured by the several makers, these mandrels differ but little in length and details of design. They should be made of a good grade of tool steel, carefully hardened with the centers lapped true after the hardening, and the body ground cylindrically true upon these centers, it being rotated upon stationary or dead centers for this last operation.

When the greatest possible accuracy is required it is considered best to make these mandrels of tough, unannealed tool steel, with the ends only hardened. This arises from the fact that the steel if hardened throughout changes somewhat in form and receives temper strains, which, although relieved in the grinding, does not allow the tool to immediately take its permanent set. For this reason a mandrel that has been hardened throughout should be first rough ground, leaving a small amount for final finishing. This finishing should not be done for some time after the rough grinding, thus allowing the tool to season and to acquire permanent set. The set will not be appreciably altered if only a very small amount is left for the final finish.

Hardening makes the mandrel stiffer and less liable to surface injury than in the case of the unhardened one. It is not, however, for the purpose of allowing careless workmen to run their cutting tools into its surface with the idea that it will not be injured thereby. Cutting tools are usually made of a higher grade steel than the mandrel, and often tempered harder, in which case the mandrel suffers if the tool comes in contact with it.

These mandrels are usually tapered about one-hundredth of an inch to the foot, the diameter being exact at the center. The size is stamped on the flat at the larger end. They will fit
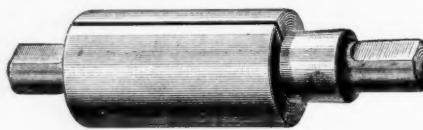
FIG. 188.

holes reamed with standard reamers, although the taper prevents uniform grip on the work at the two ends of the bore. In forcing these mandrels into the bore, good judgment must be exercised, as they constitute a wedge, which will produce enormous pressure if forced too hard, resulting in bursting the work if hard and brittle, or if soft in permanently enlarging the bore and giving it a taper corresponding to that of the mandrel.

The use of the hardened and ground mandrel does much toward the preserving of uniformity in the size of holes, in the work of shops, where these tools are used. A hole only a few thousandths of an inch under or over size prevents, in the first case, the mandrel from entering, and in the latter allows it to fall through. Its slight taper makes it a good comparative gauge by means of which minute differences in diameter of bores may be compared by the relative distance to which the mandrel enters.

Expansion mandrels, while possessing the decided advantage over the solid ones of a parallel grip in the bore of the work, have too often the disadvantage of complication of parts, which makes them unsuitable for the most accurate work, and especially so after they have become somewhat worn. These objections, however, can hardly be said to exist in the case of the mandrel shown in Fig. 188. This mandrel consists of a cast-iron bushing, having a tapered bore, which fits accurately the taper of the mandrel. The bushing, which is ground externally, parallel and to exact diameter, is split partly through at two points, and entirely through at a third, thus allowing for a slight expansion when the mandrel is driven in. Three bushings varying by sixteenths for the smaller and eighths for the larger sizes may be used on each size of mandrel. The taper used as ½ inch per foot, the bearing surfaces being accurately

ground. It is evident that the allowable amount of expansion is small, yet sufficient to grip firmly in an accurately sized hole. An attempt to expand this bushing in an oversized hole would result in cracking it; a thing that would happen before the bushing, due to its expansion, would throw the mandrel appreciably out of true. The bushings are regularly listed from ⅜ inch to 3⅜ inches in diameter, requiring eleven mandrels for the complete set.
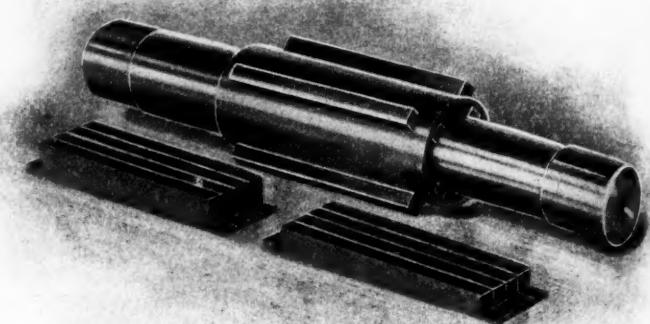

FIG. 189.

The mandrels shown in Figs. 189 and 190 expand through all sizes within their range. The one shown in Fig. 189 consists of a hardened and ground mandrel of quite steep taper, four jaws and a containing band of seamless drawn steel tubing. The jaws which fit the slots in the band nicely are concaved on their inner edges to fit properly the ground surface of the mandrel. The outer edges are ground parallel. Forcing the mandrel through the jaws expands them. These tools are regularly made in eleven sizes, taking from ¾ inch to 7 inches. On those running between 1 inch and 2½ inches two sets of jaws are furnished for each mandrel, and above 2½ inches three sets.

The mandrel of Fig. 190 consists of three stepped jaws, capable of end motion in three splines, which are milled in the body of the mandrel at a considerable angle with the axis. The head A, which moves over a parallel portion, E, of the mandrel is recessed at C to receive the notched ends of the jaws, thus holding them in the same relative position. In operating, the jaws are moved to the small end of the mandrel, the work placed
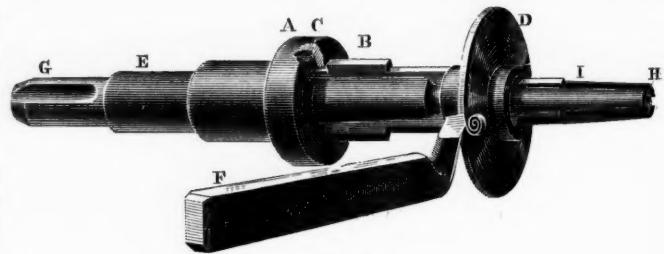
FIG. 190.

on the proper step and the mandrel forced through, the jaws expanding to the bore of the work. This tool is made in four sizes, fitting all bores from ½ to 4 inches.

When it is necessary to face a piece of work that is being driven on a mandrel close down to the bore, the expanding types, as shown above, have the advantage over the solid mandrel, since the work can be left projecting slightly over one end of the bush or jaws, which allows room for the cutting tool to pass over the edge of the bore.

Frequently it becomes necessary to machine work, the bore of which is other than cylindrical, on a mandrel. When the cross-section of such bores is circular, a cone mandrel can be used to advantage. Such a tool is shown in Fig. 191. It is strictly a special tool, as its range of adaptability is small. It is necessary that the faces, A A, of the work be machined at

right angles to the bore before placing on the mandrel, as otherwise the work will not be held concentric with its axis. The coning bush, B, may be shrunk on, pinned or threaded to the mandrel, and C should be keyed and backed up with a nut. These bushes should be turned in place on the mandrel centers.

For mandrels of large diameter the form shown in Fig. 192 is frequently used. Here the draw bolts, A A, two to four in number, take the place of the nut in the preceding figure. As before, one disk is secured to the mandrel and the other keyed but capable of motion over it.

In Fig. 193 is shown a kink in mandrels that for some classes of work can be used to advantage. As with all tools of this class it should be reasonably well made, accurately finished as to diameter and parallel. A short piece of round drill rod serves for the roller which lies in a milled groove that is a few thousands of an inch deeper at the back than the diameter of the roller. In operation, the first start of the work to turn wedges the roller between the slot and the wall of the bore, holding the work firmly from turning. A slight backward turn releases it, and the mandrel can be slipped out without pounding. The bore of the work must fit the mandrel exactly, as the slack is all taken up on one side, which will throw the work out of true if loose. This mandrel would not be suitable for work on which the pressure of the cut was in the direction of its axis, as in most milling and planing between centers.
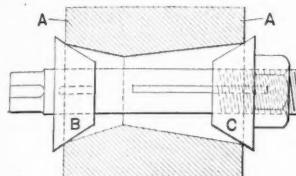

Fig. 191

Fig. 192

Fig. 193

Fig. 194

When the bore of the work is threaded, the mandrel must be provided with a thread to fit the bore, and a radial face, against which the work screws to a stop. This is commonly known as a nut mandrel, and in its simplest form is shown in Fig. 194. Work that is to be finished on this mandrel should at the time of threading, if possible, have one face turned at right angles to the bore, so that it may seat squarely against the face. This, however, is not possible when the work is tapped, as is the case with nuts. Since, for rapidity of manipulation, the mandrel should not fit the thread of the work too closely, an untrue seat cocks the work, and it is not faced squarely. The ball seat face of the mandrel shown in Fig. 195 overcomes this difficulty very nicely.

In finishing round, smooth machine parts on a screw or nut mandrel, they usually tighten under the pressure of the cut so firmly against the face, that it is difficult to remove them without injuring their finish. The mandrel shown in Fig. 196 is a valuable tool on work of this character. The collar A forms the bearing face F and is keyed to the mandrel, the spline allow-


FIG. 195.

FIG. 196.

ing it to slip back when the nut B is slacked, and thus relieving the pressure between F and the face of the work. By using a finer pitch thread in B than the mandrel thread, C, or a left-hand thread in B, when C is right hand, the collar may be omitted. This makes a cheaper mandrel, but is not so good, as the nut and work lock so firmly that considerable force is usually necessary to start the former. When the work is to be

faced the threaded portion of the mandrel should be somewhat shorter than the thickness of the work, thus allowing the cutting tool to reach the tops of the threads in the bore without injuring the mandrel threads.

A stub mandrel is one used in the end of a piece of work, as shown, for example, at A in Fig. 197. These generally fit a tapered seat, and are special in character.

Mandrels will usually drive the work by friction. If the work is large in diameter for the size of the bore, it should be
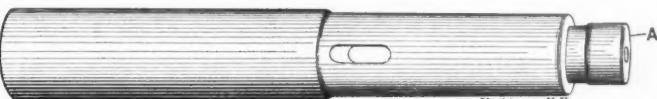

Fig. 197.

driven, if possible, from a point near the circumference, independent of the mandrel. A mandrel the surface of which has been oiled slightly, will drive nearly as well as if dry, and the chances of abrasion, in case of slipping, with its certain injury to tool and work, materially decreased.

Mandrel center bearings are often made too small to wear well, as the intense pressure between the machine center and the bearing prevents proper lubrication and increases the chances of breaking off the center. A shallow trench, cut to the point of the machine center on the top side, improves the chances of getting oil to the bearing and does not injure the center, the pressure on it being generally from the under side. When rotating between rigidly clamped centers, the slight expansion of the mandrel, due to the heating of the work, will frequently increase the pressure between centers and bearing sufficient to force out all lubrication, and cause abrasion of the surfaces, which is certain to ruin the bearing. This trouble is most likely to occur when the work is rotating at a high rate, as for filing or polishing. This bearing should, therefore, be of liberal size and well lubricated.

Since the value of a mandrel depends largely upon the con-
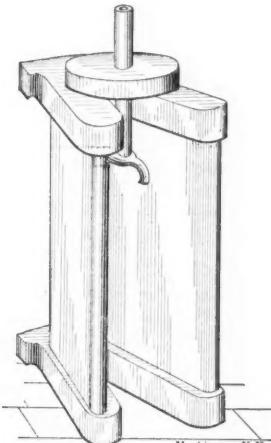
FIG. 198.
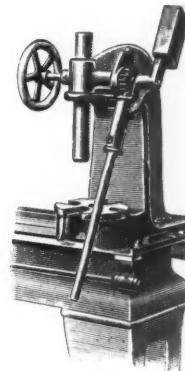
FIG. 199.

dition of its center bearings, it is very important that they be carefully protected from injury in driving. Nothing harder than a copper hammer should be used on the mandrel ends. A babbitt hammer or raw-hide mallet is preferable. If these are not available, a block of tough wood, end grain, must be used under the common hammer. The mandrel block shown in Fig. 198 forms a solid support for the work while the mandrel is being driven in or out.

The best practice dispenses entirely with driving and presses the mandrel into the bore. A press designed for this purpose is shown in Fig. 199. It is made in several sizes, and forces mandrels squarely without injury to them or the work. It is a civilized way to do it.

* * *

The days of the cable road are numbered, except where it must be used for steep hill climbing. Not only is it giving way to electricity in this city, but the Columbia Railway, Washington, D. C., which has one of the most perfect cable systems in existence, is to make the change; and this is only one of numerous instances that frequently come to light.

MACHINERY

The receipt of a subscription is acknowledged by sending the current issue. Remittances should be made to THE INDUSTRIAL PRESS, and not to the Editors. Money enclosed in letters is at the risk of the sender. Changes of address must reach us by the 15th to take effect on the following month; give old address as well as new. Domestic trade is supplied by the American News Company or its branches.

We solicit communications from practical men on subjects pertaining to machinery, for which the necessary illustrations will be made at our expense. All copy must reach us by the 5th of the month preceding publication.

FOREIGN AGENCIES OF MACHINERY.

AMERICAN MACHINERY IS THE TITLE OF THE FOREIGN EDITION OF THIS JOURNAL, WHICH IS PRINTED ON THIN PAPER AND COMPRISES ALL MATTER IN THE DOMESTIC EDITION. THESE TWO EDITIONS AGGREGATE THE LARGEST CIRCULATION OF ANY PUBLICATION IN THE MACHINERY TRADE.

FEBRUARY, 1899.

THE THROTTLING ENGINE.

There are two methods of regulating the speed of a steam engine. In the more primitive type, known as the throttling engine, the regulation is effected by varying the pressure of the steam as it is admitted to the cylinder, while in the more advanced type, known as the automatic engine, the speed is regulated by varying the point of cut-off, and thus the quantity of steam that is admitted at each stroke.

With few exceptions the best and most economical engines are of the latter class, the advantages of the automatic system being that it affords close regulation and allows the admission of steam at nearly full boiler pressure up to the point of cut-off, which is favorable to economy.

We would like to raise the question, however, as to whether the throttling system could not be used to advantage in many cases where the automatic cut off is now employed. The first objection that might be raised is that of regulation. The governor of the automatic engine regulates at the point of cut-off only, and if the speed of the engine changes at any part of the stroke up to nearly this point the governor will usually have time to vary the quantity of steam admitted for that same stroke. The throttling governor, however, regulates through the whole period between admission and cut-off, and its full effect cannot be realized until the following stroke, unless the change in load comes at the very beginning of the stroke. This is the theoretical advantage of the automatic engine, as far as regulation is concerned, but we do not know of any positive evidence that in the case of medium and high-speed engines materially better results can be obtained with one type than with another. One of the leading electric light engines now on the market regulates by throttling, and, as far as we have been able to learn, in a satisfactory manner. It must be remembered, also, that the fly wheel of a throttling engine may easily be made more effective than the same weight of wheel on an automatic engine. In

the throttling engine cut-off must take place late in the stroke to keep the terminal pressure within reasonable limits, and this gives a more uniform pressure throughout the stroke than can be obtained in the cylinder of an automatic engine.

In the matter of the economical use of steam, let us first consider a plain slide-valve engine, in one case throttling and in the other case automatic. When running automatically, it is desirable that the cut-off should occur early enough to give a low terminal pressure; but early cut-off with a plain slide valve necessitates early compression and consequently large clearance spaces to compress into—a bad feature for economy. The throttling engine, on the other hand, can be designed to cut-off late without causing too high a terminal pressure, and the compression will be correspondingly reduced, and will require a smaller clearance space. With an engine of this type, the throttling engine should not be at a great, if any, disadvantage, besides being cheaper to construct.

In the use of higher pressure steam in the engine cylinder, the automatic engine has an undoubted advantage. It is sometimes claimed that the superheating which occurs through wiredrawing the steam, as it enters the cylinder of the throttling engine, offsets this advantage, but as this superheating can amount to only three or four degrees at best, or only a very small percentage of the total heat in the steam, while the initial condensation is liable to be from 25 to 50 per cent. of the entering steam, it is not clear how the slight superheating can result in much saving. The throttling engine probably has less loss from condensation than the automatic, which is about the only claim it can make on the score of economy to off-set the use of high-pressure steam expansively in the automatic. It should be noted, however, that automatic engines generally have a valve gear giving a good steam distribution, with small clearance and separate passages for the exhaust, conditions that are seldom met with in throttling engines, and it is not at all certain that if the latter were designed with like advantages they would not show excellent results.

When it comes to running an engine under a widely varying load, the throttling engine is quite likely to show up even better than its aristocratic brother. It is well known that when the cut-off is shortened beyond the most economical point, the steam consumption will rise rapidly and this is especially true of compound and triple engines, where the economical limits for the point of cut-off are comparatively narrow. So, if an engine is to be run at reduced power part of the time, it is possible that the throttling engine would lead on the score of economy.

We have not presented figures nor made any definite claims for the throttling engine, because we do not know of any conclusive information upon the subject. But we believe that the few suggestions made will indicate that under certain conditions a well-designed throttling engine should have other claims for attention than low first cost. Considering the price at which it can be built, there must be many places where it could be used to advantage, instead of the automatic, and on higher class work than it is generally given to do.

* * *

We recently published an item regarding an old sign in possession of the Western Society of Engineers at Chicago, in which the words "Harper's Ferry," painted in black, stand out as boldly as when they were first formed by the artist's brush, while the wood around the letters, which was painted with white paint, has worn away about one-sixteenth of an inch.

Mr. Wm. Hooper, of Ticonderoga, N. Y., writes in this connection: "I have seen signs that have been painted with black paint directly on the clapboard of the building. The lettering was good after the paint on the balance of the building had disappeared, and after this the whole building was painted over, lettering and all, and the lettering obliterated; yet within ten years afterward the old black lettering appeared again quite freshly to view. I suppose the paint for the lettering was made of linseed oil and lampblack. I believe, however, that finely ground graphite mixed with pure linseed oil will last as long, or longer, than any other paint ever known of or used. I had a large iron casting which laid in my mill yard for over thirty years. It was painted with only one coat. The old casting was broken up and sold for old iron last month, and I noticed that the paint on the pieces of casting, even after being broken up, looked quite fresh."

NOTES BY A ROVING CONTRIBUTOR.—11.

THE WESTERN METROPOLIS—CABLE RAILWAYS—PIPE MAKING BY THE MILE—GALLOWAY TUBES AND WATER WHEELS—WHO IS THE MECHANIC?—A FRONTIER EXPERIENCE IN FITTING— BUILDING MARINE ENGINES ON BLOCKS.

I am at the metropolis of the Pacific Coast. The city is, like Jerusalem, set on hills; not high ones, but high enough and steep enough to furnish an incentive for inventing cable railways, which have spread widely over the world from here, and unfortunately are now too nearly obsolete to furnish much useful material in these notes. I pass them with the remark that they are much better than those made in the East, and must remain here in a good many cases. No vehicle impelled by auto-traction can get up these hills. It is a kind of angular elevator system that operates without accident and affects the price of property along the lines, otherwise inaccessible, to a wonderful degree.

This city has a "cinch" on the harbor problem. For a thousand miles or so Nature has neglected to indent the coast for harbors, and then made up for the neglect by creating here an inland sea, with a perimeter of 500 miles, filled with bays, islands and creeks, and forming the outlet for the principal rivers of California.

The city from its environment and the force of natural and mainly external circumstances, has in forty years been forced up to a population of about 350,000. It should be twice as many, but the "colonists" have never risen much above the idea of a dependency on the East, the merchants especially.

There are many, but not enough, Scotchmen here. One I met on the train said: "San Francisco is an overgrown village, spoiled by speculation. The people built their business houses fronting the East, with the rear to the water, and look inland for trade and inspiration. The great markets to the West and South are hardly considered. The merchants spend their time in studying how to get from their next door neighbor a dime for five cents' worth of goods imported from their friends in the East. The present generation will remain colonists to the end."

I have since then seen a good deal of evidence of this, too much to write about, until I am safely out of here; besides, I am far too prejudiced to judge fairly of the distributing trades.

The machine shops, mostly owned or managed by Scotchmen, are provocative of wonder. I went into an old rookery that would pass externally for an antiquated soap works and found thirty draughtsmen at work there. I asked one of the officers what line of work was done in the establishment. He was amused at the question and answered: "Well, we are making thirty miles of 36-inch water pipe just now, some water wheels, a sugar mill or two, a few quartz mills, sluice valves, and so on. We make wheel barrows and locomotives, steamships and iron picket fences." And it was true.

They never trouble about classification of work; everything is made from drawings, and most of the patterns are taken for fuel as soon as used. The buildings are to keep the rain off (in part) and as the company has several acres in the heart of the city they know better than to build permanently, and then be driven out to the suburbs by the mercantile people, who can pay more for ground.

"We went to the "pipe shop," of itself a large works, and there the thirty miles of pipe lost some of its terrors. I had seen some pipe making done before, but not in this manner. The sheets moved forward on carriages, multiple punches at work on each edge, about one hundred strokes per minute, were picked up, rolled and moved forward in a "procession." There are three towers, hydraulic riveting apparatus and running chains to move the sections of pipe, first to the caulking floor and thence across the street, on a bridge, to a lake of hot pitch. No human word could be heard in this department; the thunders of Niagara, or a salvo of artillery even, would not count against ten thousand strokes a minute of pneumatic riveting machines. We got out of range so as to talk when I ventured on the expression, "This beats all;" and my Scotch guide answered, "Yes, we beat them all out here and Eastern makers don't fool with this kind of work." These pipes were to stand a high pressure and looked like boiler shells, as indeed they might have been twenty years ago.

They were welding up galloway tubes in the "smithery,"

nearby stood a tangential water wheel 30 feet in diameter and before we got around, we stumbled on a whole plant, just improvised, for making electric "bond wires." By this time I was confused and left to think over the lesson afforded by such an establishment. It affords many lessons, too many to be noted here. Among other things, a doubt as to whether a young man can learn to be a mechanic in one of our "organized" shops. What is a mechanic, anyhow? Is it the man who can scrape a surface plate, or the one who can bore out twenty stamp mill cams in a day? Both of these are required—stamp mills and surface plates; especially the stamp mills. The writer once achieved the dignity of a foremanship in a frontier shop, and as an exceptional circumstance had some work to fit up that required scraping to a fit. I had some tools made, picked out my best man and showed him how to "take out the spots." He watched me closely and then said, "If you expect me to work at this kind of nonesense you are mistaken." He put on his coat and walked out insulted at the idea of becoming a "shoemaker." I have worked in shops where thousandths of an inch was a common unit for dimensions, also in places where a carpenter's steel square was the standard, and found the latter called out the most thinking and skill.

Almost any one can do good work with good tools, material, time and other facilities, but it takes a good mechanic to do a tolerably good job without any of these. In Geneva, previous to the introduction of American machines for watchmaking, the finest work was done with implements that could not be used now. Fifteen years has made the change. The question is, which were the true mechanics, the hand workers or the machine tenders? And the answer is, neither. The mechanic was the man who made the machines. A carpenter was once a workman in wood; now he has a hammer, saw and a pocket for nails, and fastens up "mill work." These are great economic facts acting upon the social relations of the world in a vigorous way, and it is a real pleasure to now and then drop in among the old-fashioned workmen whose functions differ from the machines they use. Here, on the Pacific Coast, where a diversified market demands all kinds of things to be made, not in hundreds or in one manner, but each thing in a different way each time, is such an opportunity.

At Southampton, England, in the olden time, there was a marine engine works I once dropped into and found a large engine, or pair of engines, near completion without anything about the place one could call a modern machine tool. The work was done on blocks, so to call them, and all to accurate lines. Some conference with the owners disclosed the fact that they were fully aware of the results attained by ponderous implements, and if the men in their works were changed, the business would have to stop, but the men had learned to employ portable apparatus for drilling, planing and boring, and with a few cords of blocks and some sole plates could go through with a marine cylinder, after it was bored, at less expense than if they had the large tools that would take the place of this blocking and setting. The circumstance was brought to mind by seeing a good deal of this kind of work going on here. One firm was constructing a large machine in the street, because, as one of the men said, "we cannot get it into or out of the shop; besides," he remarked, "the rent is cheaper out here."

A fair inference from these remarks will be that the equipment in these works is bad. It is not bad, but good, and mostly modern, because antiquated tools cannot survive the work.. A stamp mill, to crush 100 tons a day, is built and shipped in fifteen to twenty days—good strong work. I am told that the work is sometimes painted on the truck while on the way to the railway or steamer. The great works, the Union Iron Works, I will leave to the last.

* * *

Important mechanical information contained in a leading New York daily:

"The pulley which broke on the Lexington avenue cable road was a shreave pulley."

"Coremaking consists in building up cylinders of sand, one inside of the other."

"Cyanide of potassium crystallizes in eight-sided cubes." (Manufacturers who buy alleged cyanide of potassium and find it crystallized in seven or nine-sided cubes will now be warranted in not accepting it, as it probably would fail to harden the work.)

THE CORLISS ENGINE.—3.

### DETAILS OF VALVE GEAR, SAFETY STOP AND VALVE SETTING.

A. H. ELDREDGE.

After having located the various points of attachment of the valve, hook and eccentric rods, and having the travel of the same, and the throw of the eccentric determined, attention should be paid to the details of construction of the various parts of the valve gear.

An easy method of constructing the steam and exhaust brackets is shown in Fig. 1 of December MACHINERY. This construction permits the brackets being easily turned and finished in the lathe at slight additional expense, a thing only possible by hand work with many of the odd-shaped brackets now in use. It also offers an easy bracket to cast and a much stronger one when finished.

The bell crank, steam, exhaust and knock-off arms can be made with parallel faces, while the two arms of the bell crank lever can come in the same plane, as shown in Fig. 1, Article I., and in Fig. 9. This construction permits the faces of the arms to be machined and finished better and cheaper than the ordinary arm of elliptical cross-section.

A finished valve gear is always an attractive feature to an engine, and it offers greater inducements for an engineer to keep it clean and properly adjusted than an unfinished one. Where the design is such that the parts can be easily cast and machined, a finished valve gear offers little additional cost to many of the unattractive, unfinished ones now in use.

Fig. 15
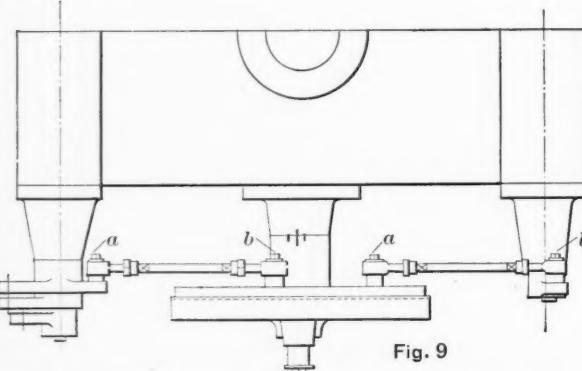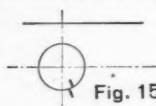
Fig. 9

The steam and exhaust rods should be attached to the inside of the bell crank and exhaust arms, and to the inside of the wrist plate, as shown in Fig. 9. This permits the rods to be removed by simply taking off nuts (a) and (b), thus making it possible to make any repairs to the steam or exhaust valve mechanism, such as putting in a new packing behind the brackets, etc., without in any way disturbing the wrist plate or the rest of the valve gear; points a designer will appreciate once he is placed where a number of bright erectors can pound away at him for a few years.

The nuts used about the valve gear should be countersunk sufficiently to cover the thread of the rod and prevent the waste being caught there every time the engine is wiped up.

The Hook Rod Attachment.

There are numerous ways for attaching the hook rod to the wrist plate. One method is shown in Fig. 1, Article I., and is known as the Barclay double wrist plate. It consists of two plates mounted side by side, as shown in the figure. The hook rod (B) is attached permanently to the outer plate, while the steam and exhaust rods are attached to the inner plate. A pin, not shown in the drawing, is arranged so as to connect or release the inner plate from the outer one at will. When the two plates are connected, the inner plate will be driven through the outer one and rod (B), but when disconnected the outer plate will still move with rod (B), while the inner plate will stand still unless worked by hand through the starting bar. This device works nicely on small sized engines where but one eccentric is used.

The old style drive, from which the hook rod takes its name, is shown in Fig. 10. When it is desired to work the valve gear through the starting bar, the end of the rod is raised by hand and a block (b) is placed between the rod and pin for the rod to slide on as it moves back and forth over the pin. A small pin (a) keeps the rod from jumping out of place when the engine is running. In large engines, where the rod is heavy, an eye bolt is often provided, as at (C), from which the rod can be suspended when desired.
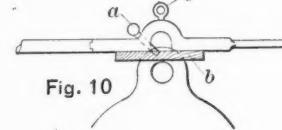
Fig. 10
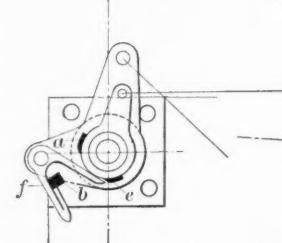
Fig. 11
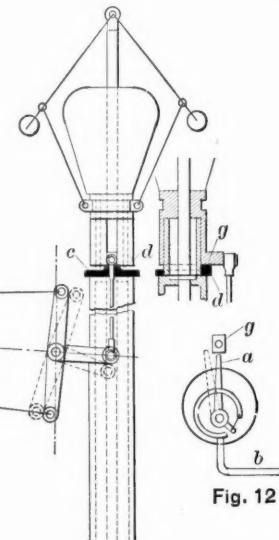
Fig. 12

The E. P. Allis engines are provided with a boss on the wrist plate that is fitted with a loose sleeve through which the hook rod can slide back and forth. A pin in the end of the boss is arranged to fit into a hole in the hook rod for driving the wrist plate, but can be released at will, thus providing means for working the valve gear by hand. This device is one of the most satisfactory of any in use up to the present time.

Safety Stops.

First let us define a safety stop. It is a device, usually attached to the governor of an engine, that will automatically shut down the engine in case of accident to the governor of its driving mechanism. Sometimes it is attached to the fly wheel and shuts down the engine automatically when the speed is above the normal.

The requirements of a safety stop are:

First. It should be perfectly automatic.

Second. It should allow the engine to run at its greatest range of cut-off without danger of shutting down.

Third. It should automatically shut down the engine when the speed runs above the normal.

Fourth. It should be simple and should provide a ready means for quickly stopping the engine in case of case of accident to any of the machinery of the plant.

Requirement third can be, though it seldom is, taken care of by the governor itself, and need not be considered where the governor can be relied on for this work. Fig. 11 shows how this is accomplished. When the governor is at its highest position

clip (a) will strike hook (f), forcing it away from hook pin (b) at the beginning of the stroke, thus shutting off steam and stopping the engine. Whether or not the governor can be relied on to do this work will be taken up later.

One of the simplest forms of (so-called) safety stops is shown at (c) Fig. 11. It consists of a collar (c) having a projection (d) at the governor, and a safety clip (e) on the knock-off lever. When the governor rests upon (d) the clip (e) will not strike the end of hook (f), leaving the engine in its starting or running position, and also the position of greatest cut-off. When the engine is started up the governor will raise, and as soon as it is up to speed some one should turn collar (c) so that (d) will not be under the govern arm (g). Then should the governor belt break or a key work out of one of the gears, the governor will fall to its lowest position, resting on the narrow part of collar (c). This will bring the knock-off lever to the dotted position, in which position safety slip (e) will strike the point of hook (f), forcing out so that it cannot latch with hook pin (b), thus preventing the steam valve from opening, and consequently stopping the engine.

It will be seen that this stop does not fill one of the requirements for a perfect stop. It is not automatic. In case of a railroad engine, where it is often necessary to carry steam to the maximum range of cut-off or full stroke, it is necessary at times to block the governor up or the governor will drop to its safety position and stop the engine. It has no control over the engine speed. And, lastly, it is not accessible in case of accident.

A modification of this stop is shown in Fig. 12, and is known as the Barclay safety stop. It consists of a Bourdon tube, similar to those used in a steam gauge, and mounted on the side of the governor shaft. The lower end of the tube is connected by pipe (b) to the steam chest of the engine, while the
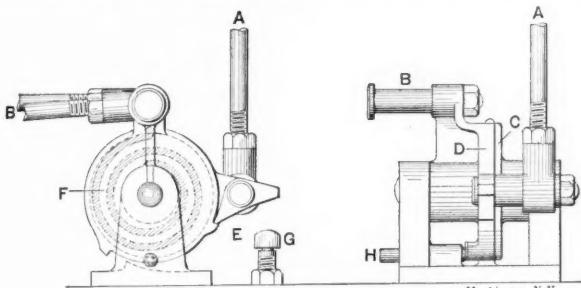

FIG. 13.   FIG. 14.

upper end is connected with lever (a). When there is no pressure on the tube (a) will stand in a vertical position, holding up the governor arm (g), and keeping the knock-off lever and safety clip (e) in the starting position, the same as with the safety collar. When steam is admitted to the cylinder and the engine comes up to speed, the governor raises and at the same time the tube expands, throwing arm (a) into the dotted position, where it will remain until the steam is shut off. The safety device will then act the same as with the safety collar in case of accident to the governor or governor belt. When the engine is stopped the pressure in the tube is released and lever (a) will come to the vertical position in time to arrest the descent of the governor. This device is, therefore, better than the first, inasmuch as it is automatic. However, the whole automatic principle may be destroyed should a valve be placed in pipe (b), which in a number of cases the writer has found necessary, owing to the bursting of the Bourdon tube.

A safety stop that represents a decided step in advance is furnished with the Bates Corliss Engine, and is illustrated in Figs. 13 and 14.

"C and D are independent discs between which is placed spring F, connected to the hub of C and rim of D. The tension of this spring is resisted by pawl E on disc C, thus causing discs C and D to work as one. Rod A connects direct to the governor. Rods B connect to tripping device at valve motion. Should any accident befall the governor, it would immediately descend until pawl E came in contact with adjustable screw G, disengaging it from disc D, thus allowing the spring F to throw the rods B back to the earliest point of cut-off, shutting off steam and stopping the engine. When the engineer stops his

engine and the governor descends, he pushes pin H into a recess in disc D, thus stopping the downward travel of the governor at a point where pawl E will lack just a trifle of being in contact with adjustable screw G. When the engine is started in motion again, and the governor rises, the pin H is automatically forced out, leaving the automatic stop free to act."

This stop is perfectly automatic. Forgetfulness on the part of the engineer simply means that he must set the stop before he can start the engine. The danger of shutting down at heavy loads is averted, since it does away with clips (e), Fig. 11. It can be easily operated in case of accident to any part of the machinery. It does not fill requirement. Third, although that can be easily provided for, as will be taken up later.

The Safety Appliance Co., at Elmira, N. Y., have brought out a safety device that can be attached to any engine. It consists of a weight mounted in the fly wheel; on one side of the weight is attached a spring to resist its centrifugal motion as the engine speeds up. The weight also has a projection that will be thrown out far enough to strike a stationary rod, located beside the fly wheel, when the speed of the engine is above the normal, starting in motion a chain of mechanism that will close the main steam valve and stop the engine. In time this device will no doubt be so simplified and cheapened as to warrant its use on many, other than Corliss, engines.

Before going further with the governor question, a few directions for valve setting will be given:

Directions for Valve Setting and Governor Adjustment.

First. Remove the steam and exhaust valve bonnets, and upon the end of the valve will be found a mark corresponding to the opening edge of the valve, and upon the cylinder a mark corresponding to the opening edge of the port, Fig. 15. The direction of motion for opening the valve can be determined by working the wrist plate by hand.

Second. Examine the wrist plate hub and bracket. Upon the bracket will be found a mark corresponding to the central position of the wrist plate, and upon the hub will be found three marks, one locating the central position of the wrist plate and two others locating the extreme travel of the plate in either direction of motion, Fig. 9.

Third. See that the rocker arm travels an equal distance each side of its vertical position. To do this loosen the eccentric and rotate it slowly about the shaft, then with a plumb bob and measure the distance the rocker arm travels each side of its central position. Adjust the length of the eccentric rod to bring the distances equal.

Fourth. Rotate eccentric about the shaft and see if the wrist plate travels equal distances each side of its central position, as shown by the travel marks. If it does not, adjust the length of the hook rod to bring them equal.

Fifth. Block the wrist plate in its central position; then pull up the dash pot rods until the hook pins engage with the steam hooks; adjust the length of the steam and exhaust rods until the valves have the proper amount of lap, as determined by the size and kind of engine.

Sixth.—Throw the wrist plate, with the starting bar, first to one and then to the other extreme position, and adjust carefully the lengths of the dash pot rods, so that the steam hooks will latch with the hook pins when the wrist plate is at its extreme travel, allowing one-thirty-second inch to three-sixty-fourths inch clearance.

Seventh.—Place the engine on dead center, then see that the hook rod is fastened to the wrist plate. The eccentric should then be* turned in the direction of the engine is to run until the proper amount of lead is secured; fasten the eccentric to the shaft and place the engine on the opposite dead center and measure the lead; if it is not the same, make it the same by adjusting the lengths of the steam rods.

Eighth. Block the governor about half way up the slot and fasten the reach rod lever at right angles to a line drawn half way between the two rods, Fig. 11; adjust the lengths of the reach rods until the knock-off arms stand vertical. With the governor in this position turn the engine over until cut-off occurs and measure carefully the distance the cross head has traveled; place the engine so the cross head will be the same

---

* Should the hook rod be attached to the bottom of the wrist plate, or the direction of motion of the eccentric be in any way changed, then the reverse would hold true.

distance from the other dead center, and adjust the length of the reach rod until cut-off will just occur. This insures equal cut-off at each end of the cylinder for these positions. See that the governor gag pot rod is properly adjusted, and that the pot is filled with light oil.

Ninth. Drop the governor to its lowest position and see that safety clips on the knock-off levers are adjusted so as to prevent the steam hook from latching with the hook pin.

Tenth. Always tram your engine with a fine prick punch, so as to be able quickly to adjust it in case of accident, or in case it has been tampered with.

The following table, taken from the Corliss Engine Co.'s practice, of Providence, R. I., gives the amount of steam and exhaust lap allowed for the engines having but one eccentric. With two eccentrics the steam valve would be open three-eighth inch or more.

| Diameter of Cylinder.	Steam Lap.	Exhaust Opening.
Inches.	Inches.	Inches.
12	1-4	1-32
14 to 16	5-16	1-32
18 to 22	3-8	1-16
24 to 28	7-16	3-32
30 to 36	1-2	1-8
38 to 42	9-16	1-16

* * *

STEAM BOILER FURNACE PROPORTIONS.

WM. WALLACE CHRISTIE.

There seems to be a lack of data and certainty as to just what amount of combustion chamber contents are needed to give the best results in a steam boiler.

It would seem as though there must be some proportion between grate area, rate of combustion, the heating surface of the boiler and contents of the combustion chamber. The writer has tabulated some data for different sizes of Manning boilers, and plotted the results of some calculations therefrom.
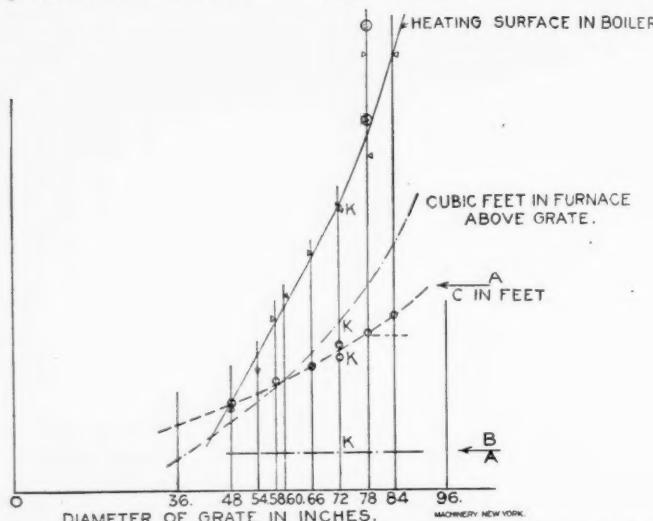
K is the plotting of a boiler tested at varying rates of evaporation, by Prof. Denton, and which gave the greatest economy when developing 99.7 H. P., with Pocahontas coal.

There seems to be a wide variation in the practice, as shown by the proportions of the last boiler in the tabulation, compared with the rest of them.

Manning "Boiler Practice," as tabulated, gives these general results:

FURNACE CAPACITY IN STEAM BOILERS.

No.	Height of Furnace.	Height Above Grates.	Diameter inside Furnace, inches. C.	Cu. Ft. in Furnace above Grate. A.	Total Heating Surface, sq. ft. B.	Col. B. ÷ Col. A.	A ÷ C in feet
1	42	36	48	37.698	569	15.10	9.42
2	42	36	54	47.712	786	16.4	10.6
3	44	38	58	58.102	1138	19.5	12.0
4	44	38	60	62.177	1276	20.5	12.4
5	44	38	66	75.233	1563	20.8	13.6
6	45	39	72	95.761	1878	19.6	15.96
7	46	40	78	110.61	2440	22.0	17.0
8	48	42	84	134.697	2880	21.3	19.2
9*	42	36	72	88.395	1854	20.97	14.7
10	8 ft. 6½ in.	8 ft.	78 in. 74 in.	265.46	2218	83.54	40.8

* This was used by Prof. Denton, who obtained best results when developing 99.7 H. P.

From many tests upon one boiler the best results were obtained when it developed 99.7 boiler H.P. at a rate of combus-

tion of 10.40 lbs. of coal per square foot of grate per hour. In this particular boiler these proportions exist:

Diam. of grate, 6' 0".
Cu. feet in furnace above grate, 88.395.
Total heating surface in boiler, 1,854 sq. ft.
Heating surface ÷ furnace contents = 20.97.
Furnace contents ÷ diam. of grate = 14.7.
Height of furnace above grate, 36 inches.

* * *

TYPICAL EUROPEAN MACHINE TOOLS,—3.
LATHES.

In the lathes presented on a full-page illustration of this issue we will at once perceive the characteristic differences which distinguish them from our home-built machines. These points have formed in our technical papers the bases of many a discussion. And, as it often happens in such matters, both sides "are of the same opinion still." On the other side the preferences are for a gap-lathe, a compound tool post, a gibed carriage and flat carriage ways, while here we incline to a lathe with straight bed, a simple tool post, a weighted carriage and V-shaped carriage ways. These remarks, of course, are only true in a general sense. The machines presented are of the smaller and more commercial sizes. Large and heavy machines are generally built for some special duty, where conditions often impose certain designs. In Europe the size of a lathe is designated by the height of its centers above the ways. Here we consider the diameter of the piece a lathe will swing. Thus, a 165-mm. lathe becomes a 13-inch lathe. From one point of view this lathe has a length of centers of 165 mm., from another, it will swing a piece 13 inches in diameter.

Another point, and one that is not fully appreciated here, is the fact that a European lathe builder will build the same size lathe with rack-feed, or screw-feed, or both; he will place the screw in front and the rack at the back of the bed, or vice versa, or both in front, or he will put the screw in the center to suit any possible preference of his customer. Here, on the other hand, the builder works out an acceptable type, and is loath to depart from it. Both have, no doubt, good arguments for their practice.   C. C. S.

* * *

NOTES FOR APPRENTICES

It is a common idea that the ability to file a true plane surface is due only to muscular skill, acquired by practice, but no amount of practice will bring success if done in the wrong way. One may, without doing any thinking, happen to get started right, and succeed without without being able to tell how it was done, but all operations of human skill at the start are greatly benefited by a liberal amount of thinking. No one can file straight until the muscles in use are trained to the plane surface motion. Therefore, the file must be guided straight from the start by some means not dependent on the operator.

This suggests at once the idea of using a planed surface to learn on, and that is good, but not always available. A beginner should never commence on a surface of less than two inches length and at least as wide as the file. If the surface is high in the middle it should be made a little hollow by chipping or grinding, so that the file will have a bearing near the ends only. It is important to have the piece placed at a height that will allow the operator to work in a natural, easy, standing position. It is not necessary to say anything about how to hold the file, for every book or article on the subject tells about this the first thing, and also it depends largely on the shape and size of the surface.

Start filing with short strokes, being careful to keep the file bearing on the two high points during the full stroke. As soon as trained to do this, the stroke may be gradually increased in length, but not in any case so much as to cause the file to lift from either of the high spots. After sufficient practice a surface 1½ inches long may be used for trial, and if successfully done, a final test may be on a surface one inch long. When you can file this straight with a six-inch stroke of file, you may congratulate yourself, and offer your services in that line.   BELL CRANK.

* * *

A leading technical paper has something to say about boring and chucking "journals." The word "journal" means the part of a shaft or spindle that runs in a bearing or box, and does not refer to the box itself. It is a word that is frequently misused.
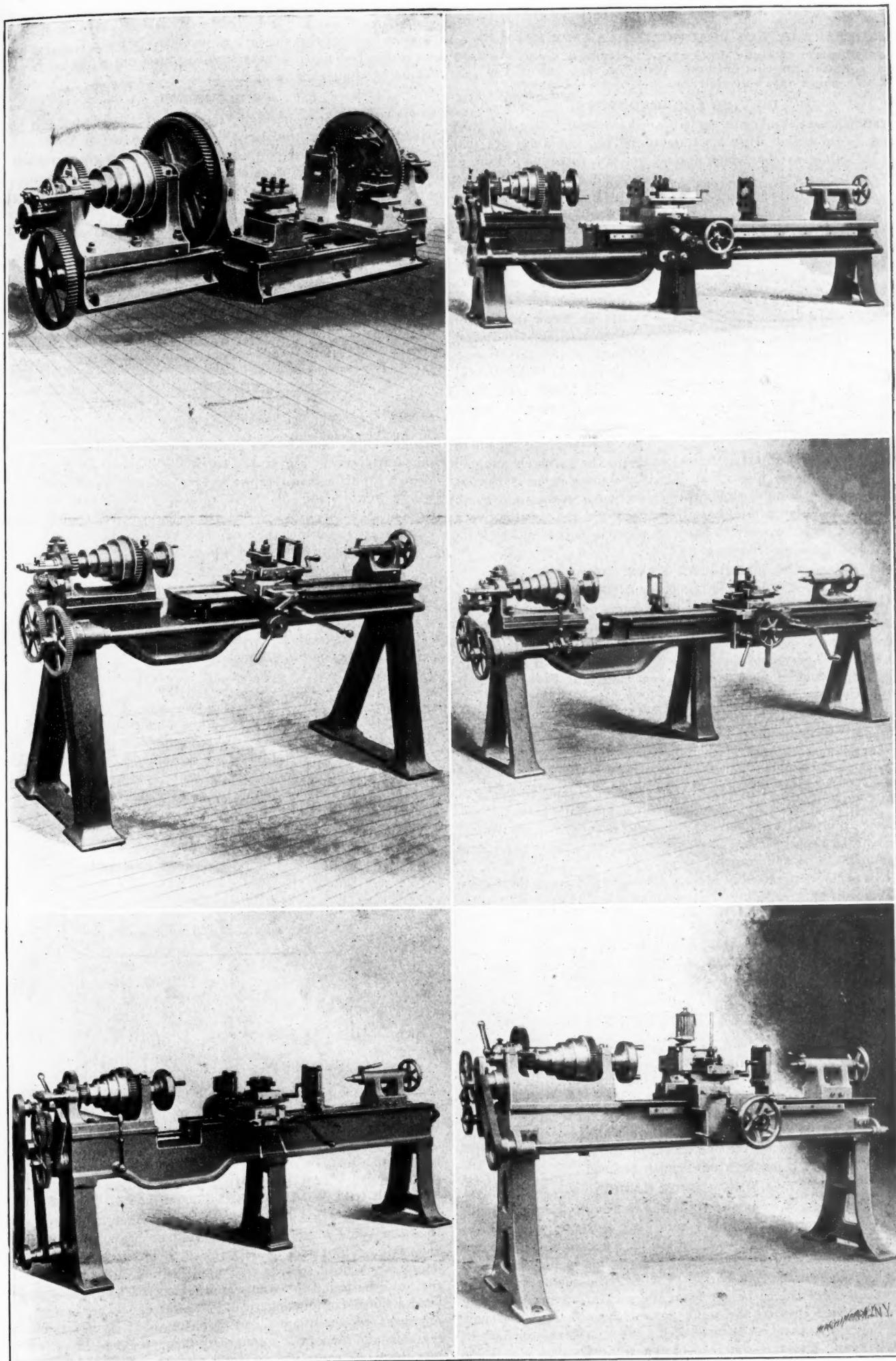
EUROPEAN MACHINE TOOLS—LATHES.

SHOP KINKS.

DRIVING FINISHED WORK.

The simplest kinks are sometimes the best and save the most
time. Mr. Arthur Munch, Brainard, Minn., sends an idea that
is as simple as the simplest, and yet we agree with him in
saying that it will prove
to be a time saver in
handling finished work
in the lathe. Most lathes-
men have a corner some-
where where they keep a
few pieces of copper to
put under the set screw
of the lathe dog when
clamping onto finished
work, or else they have a
stock of sheet metal
strips which they bend
around the work to avoid
the possibility of the set
screw slipping off on to
the finished surface. Mr. Munch writes that he has lately adopted
the plan shown in Fig. 1. It is simply a piece of brass bent at
a right angle as the work is held perpendicular in the right hand.
Then the angular strip of brass or other metal is slipped between
the work and the screw. The end marked A prevents it from
falling through and slipping.
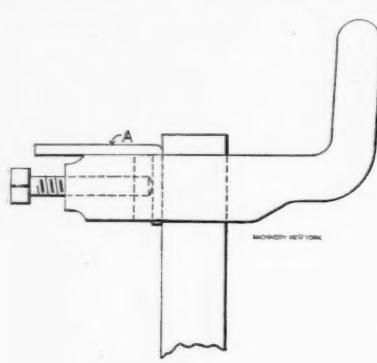
FIG. I.

MILLING KEYS.

W. F. Oliver, Plainfield, N. J., sends sketches of special fix-
tures for milling taper keys, all the fixtures being intended to be
used in the ordinary milling machine vise. The first operation
of milling the keys on the bottom is done in the fixture shown
in Fig. 2. The top of the fixture is planed 3-16th of an inch to
the foot, which is considered a good taper for keys, and four
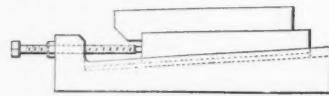
FIG. 2.   FIG. 4.
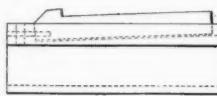
keys are milled at one time, leaving 1-32d of an inch to be taken
off their top sides. By having the adjustable feature, several dif-
ferent sizes can be milled on the same fixture, the adjustment
serving to bring the key above the vise jaws without the use of
parallels placed underneath.

The second operation of milling the sides is done in the fixture
shown in Fig. 3, with a pair of straddle mills. The fixture holds
two keys.

FIG. 3.
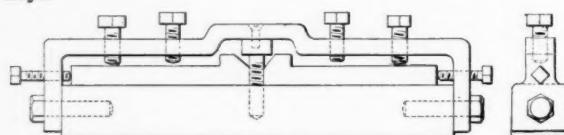
The operation of milling the keys on the top is done in a
fixture like that of Fig. 4, milling one key at a time with a milling
cutter having a face as wide as the key is long. It will be noticed
that the fixture is slotted down the center, so that when the vise
jaws are set up the sides of the fixture will clamp the key. A
small latch is used on the end as a stop for the key, and it also
makes all keys come with one length of head.

A NEW INSIDE GAUGE.

Mr. J. Riley, a toolmaker of Loughborough, England sends
a sketch, reproduced in Fig. 5, of a gauge for use in boring ec-
centric straps or other work where it is necessary to measure
behind or back of shoulders that are smaller in diameter than
the surface that is being bored. The sketch explains itself. The
gauge is intended to be set from the measuring machine, and
then be bent over at the joint, passed through into that part
of the work that is being bored, and then the end bent
back again, and the diameter of the work tested. Mr. Riley
writes that the gauge which he has made never varies as

much as .0001 inch, the joint having been carefully fitted. For
doing work quickly and accurately, he has not seen its equal,
and he believes that the idea is new. He has also found it useful
in seeing how far it is necessary to rough out a piece, by reason
of its bending over feature.

SOME HELPS.

Under the above heading "Easy Way" contributes two kinks
which we will let him describe in his own words.

How do you enjoy putting up a hanger for a countershaft, us-
ing a ladder for a foundation and holding the hanger with one
hand while turning in the coach screw with a wrench in the other

SAW CUTS AT RIGHT ANGLES.

MILLED OR KNURLED
RIGHT AND LEFT
HAND THREAD

QUICK THREAD
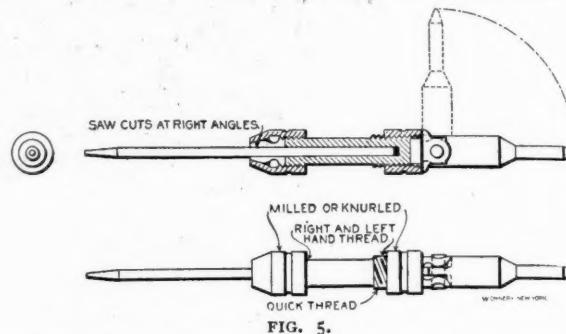
FIG. 5.

hand? Don't like it? Well, make a pattern and get some cast-
ings like those in Fig. 6, and screw the brackets up first, having
them a little slack so that the hanger can be slipped under them,
where it will hang, as shown in Fig. 7, while you adjust and
tighten it with comparative ease. The projections, a, on the
clamps are to set into the usual bolt holes in the hangers.

BEAM

SIDE VIEW

BOTTOM VIEW
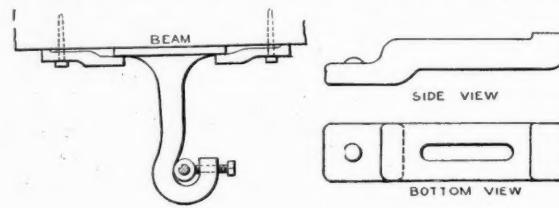
FIG. 7.   FIG. 6.

Recently. while attending to some repairs in a local printing
office, I noticed a screw driver, which is at once so very
convenient and powerful that I am prompted to call further atten-
tion to it, although it may be in more common use than I am
aware of. It consists simply of a piece of round steel, bent at

END VIEW.

END VIEW.
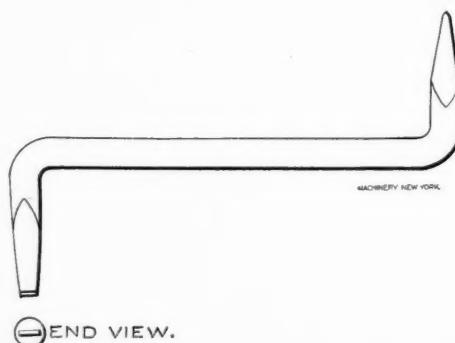
FIG. 9.

each end, with each end flattened to form the blade. Notice
that the line of each blade is at right angles to that of the other
one, allowing the screw driver to be used where one is cramped
for room.

ODDS AND ENDS—STOPPING A CHATTER—PROTECTING BRIGHT WORK—CORRECTLY SHAPED TOOLS.

C. S. Edwards, Auburn, N. Y., writes that he recently had
to make some stand bases that were of brass, and that were
very thin. They were to be screwed to the floor, with 1½-inch
countersunk head screws, and upon drilling and countersinking
the holes he found the countersink chattered badly, although he
used a fluted countersink reamer. After experimenting in vari-
ous ways, he finally put a pad of waste about ½ inch thick over
the hole, and forced the countersink through it and into the work,
and the work came out perfectly smooth.

Another little suggestion is offered by Mr. W. de Sanno, Tu-

lare, Cal., in reply to an inquiry in the last issue for something to protect bright work. He uses damar varnish, with good results, and says: "Have the work clean and free from dust. Apply with a soft camel's hair brush. The preparation will stand a fair amount of handling if not held in the hand too long."

RIGHT SHAPE   WRONG SHAPE

THIS CUTS OR SHEARS.   THIS BREAKS AND RUSHES THE IRON OFF.
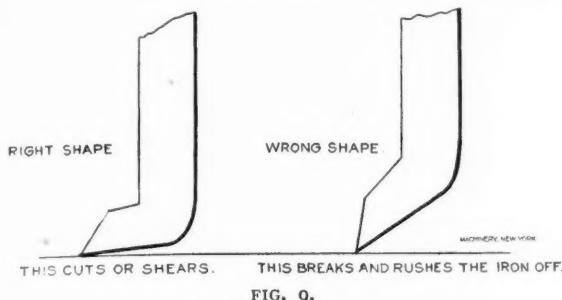
FIG. 9.

Concerning the device shown by Mr. Hugh Hill, on page 155, in the last number, for lifting a planer tool on the return stroke, J. W. H., Springfield, Vt., writes: "The leather will probably work all right with the shape tool he uses, but if he used a correctly shaped tool he would need no leather. I send a rough sketch of a rightly and wrongly shaped tool. All tools should have the least possible clearance on the face or bottom, and have the cut on the top or front. This applies to all tools."

To this the editor would like to add that the shape of the tool shown was due more to our draughtsman, who is not a practical mechanic, than to Mr. Hugh Hill. We presume that the original tool was made correctly.

A COMBINATION SQUARE.

The two accompanying sketches were made from a combination tool patented some years ago by W. H. Sleeper, of Athol, Mass. The tool has never been manufactured, however, and the one illustrated is the first and only one that has been constructed. It was made by Mr. Sleeper.

The tool is designed for a combination square that can be used either as a center square or to lay off a line at a given distance from the center of a round piece. In Fig. 10 it is set like an ordinary center square, and in Fig. 11 is shown how it can be set so as to throw the blade to one side of the center of a round piece. The construction of the tool will be understood by referring to the two illustrations. A is a casting in which slides the blade B, and to which are attached the two swinging arms. C, C. These arms, when brought together, as shown in Fig. 10,
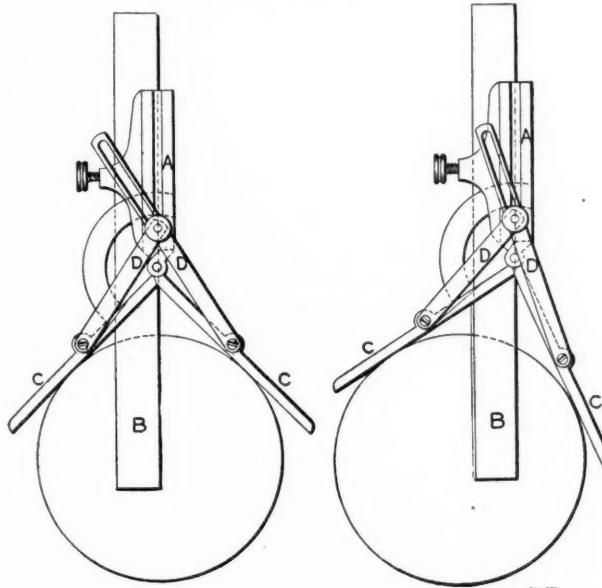
FIG. 10.   FIG. 11.

form an exact right angle with each other, and they can be accurately located by means of a stop, so that one edge of the blade will bisect the angle, thus forming a perfect center square. The right-hand arm is slotted for about half its length, making it possible to swing the blade to the right-hand side of the center of the angle, considerable further than shown in Fig. 11. The arms, C, C, are locked in position by the links D, D, which

are clamped to the slot in the casting A by means of the thumb screw shown. The proportion of these links is such, moreover, that when the arms are opened out wider than shown, and form an angle of more than 90 degrees, each arm will move equally away from the blade, and the latter will bisect the angle formed by the arms, however large the angle may be. The tool can thus be used on very large work, where it is necessary to have an angle between the arms greater than a right angle. Another feature of this construction, also, is that it permits the tool to be used on polygons for laying off radial lines. A piece of graduated steel, shaped to the arc of a circle, is fastened to the right-hand arm, and slides in a circular groove in the casting A, making a bevel protractor of the instrument.

KEEPING CHANGE GEARS.

Mr. N. J. Thompson, Toronto, Ont., believes in having a place for everything and everything in its place. He illustrates in Fig. 12 how he keeps his lathe change gears. He says: "It is handy to keep each gear on a special peg marked in plain figures with the number of threads per inch that it will cut and then, to insure against mistakes, have the number of gear that should be on that peg marked also. For example, the place for a 60-tooth gear that cuts 12 threads would be marked as in the sketch." We judge that Mr. Thompson keeps only the most used gears in this way, that are used with one particular gear on the stud,

BOSS

CUTS THREADS   12   60   Nº OF GEAR FOR THAT PEG.
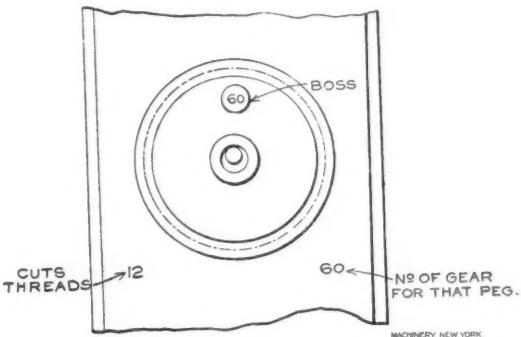
FIG. 12.

for no system could be complete that did not take account of both the gear on the stud and the gear on the lead screw. Mr. Thompson adds: "Why don't lathe builders (perhaps some do) have a small boss, as shown in the cut, cast on the web of gears on which to stamp the number of teeth? It would save lots of twisting around and wiping off grease from half a dozen gears before getting the right one."

* * *

QUICK WORK.

Railroad men are accustomed to phenomenal runs and quick time, but for really rapid work the locomotive's press representative, "Locomotive Engineering," has easily broken the record and set a pace that engineers on the road will find hard to equal. As noted in our last issue, the condition of our contemporary on the morning after the fire of Dec. 4 was, if anything, a little worse than the locomotive after a head-on collision, for there was not even any wreckage left. With the company's president at the throttle, however, and the rest of the officers and staff as crew, the January number of the paper pulled out on time, carrying, so it seems to us, rather more than the usual allotment of interesting articles and illustrations. Those who are not familiar with the numberless details incident to the publication of a periodical can hardly appreciate what it means to start with nothing and produce within less than a month a paper like this number, but all will agree that it was a noteworthy accomplishment.

In this connection it will be interesting to mention that the appraisal of the loss upon the Home Life Building, the upper stories of which were so completely burned out, places the damage at less than $200,000 on a total valuation of $900,000, about $75,000 of which was due to injury to the marble front of the building. The rest of the damage was from the destruction of the woodwork, heating and lighting systems, etc. The structural iron work suffered practically no loss. This is interesting as showing the superior fire resisting qualities of the modern tall office buildings, of which this one afforded the first thorough test.

LETTERS UPON PRACTICAL SUBJECTS.

PRONY BRAKE TEST ERRORS.

Editor MACHINERY.

The Prony brake is the most commonly used form of dynamometer, but it is subject to an error which is rarely mentioned when the results of tests are given. The error is due to the weight of the brake lever and band, which is supported by the wheel and absorbs power not represented by the weight at the end of the lever. Suppose such a brake to be used on a wheel five feet in diameter at 200 revolutions per minute. If made with a wood beam and flexible bands, lined with wood blocks, it would weigh about 100 pounds. The coefficienct of friction for wood on the turned pulley would be about .2, or twenty pounds resistance. The velocity of pulley face would be 3,140 feet, which by twenty pounds, equals 62,800 foot-pounds, or nearly 2 horse power.

If the test was 50 H.P. the error would be nearly 4 per cent. I have seen the result of such tests given to the third decimal place, yet the error due to brake weight was ignored. Sometimes a counterweight is added to balance the lever, which, it is obvious, increases the error due to dead weight. When weights are hung on the lever to weigh the load, the entire weight of the brake, weights and counterweights is carried by the pulley, and is much worse than when a platform scale is used to weigh the beam pressure. There is no ready means of preventing this error, but it can be done by suspending the brake at a point directly above its center of gravity, using a flexible connection to one end of a pivoted lever having at the other end a weight to balance the weight of the brake. The error is worse the greater the ratio of brake weight to power tested, and though in many cases it will be insignificant, yet it should always be considered where great accuracy is desired.   BELL CRANK.

WHAT ARE WE WORTH?

Editor MACHINERY:

It is rapidly approaching the time of year when many of us are beginning to wonder what our labor has brought us. We want to count our earnings, and in order that this may be done with as reasonable a degree of accuracy as possible, our thoughts naturally revert to the question of what is the best method for making the annual inventory. The task is neither easy nor agreeable, nor one concerning which there seems to be any great superfluity of knowledge, as evidenced by the astonishing diversity in results derived by different appraisers, and different methods of figuring.

A firm's principal assets consist usually of the following general items of capital:

1. Cash on hand.
2. Accounts receiveable.
3. Goods on consignment.
4. Finished stock.
5. Semi-finished stock.
6. Raw material.
7. Miscellaneous stores.
8. Valuation of plant.
9. Good will.

Of these the mechanical department is concerned with but five, viz., items 4, 5, 6, 7 and 8. The valuation of the first is, or at least, should be, shown by the storeroom books, and is usually taken at cost, including labor, material and expense. But where the stock is of a standard or customary kind, and is in constant demand at fixed prices, and no additional cost is attached to its distribution, it might be permissible to inventory it at the selling price, although this practice is not to be recommended.

With a suitable and properly installed system of cost keeping, the semi-finished stock, item 5, will appear in the Prime-cost books, which valuations should, of course, be augmented by an appropriate proportion of the general expense account. Likewise, raw-material, item 6, should be shown by the storeroom books, and miscellaneous stores, item 7, can be readily counted or weighed as the case may require. It is in the valuation of plant, item 8, therefore, that we find our chief difficulties. This item includes plant of all description, which for purposes of examination and discussion is here separated into the following general catagories:

Drawings.

A1.   Drawings of present standard machinery.
A2.   "   past standard machinery.
A3.   "   special standard machinery.
A4.   "   jigs, fixtures, etc.

Patterns.

B1.   Patterns for present standard machinery.
A3.   "   special machinery.
B3.   "   special machinery.
B4.   "   jigs, fixtures,etc.

Standard Machinery and Tools.

C1.   Standard machine tools.
C2.   Standard plugs, gauges, micrometers, indicators, etc.
C3.   Cranes, vices, chain-blocks, jacks, etc.
C4.   Drills, taps, reamers, milling cutters, etc.

Special Tools, Jigs and Fixtures.

D1.   Special machine tools.
D2.   Special cutting tools.
D3.   Jigs, fixtures, etc.

Line Shafting and Accessories.

E1.   Shafting.
E2.   Hangers.
E3.   Couplings.
E4.   Pulleys.

Office and Shop Fixtures.

F1.   Office fixtures.
F2.   Drawing-room fixtures.
F3.   Shop fixtures.

Belting.

G1.   Cone Belts.
G2.   Shifting belts.

Buildings.

Machine shop, pattern shop, smith shop, foundry.

Who will undertake to tell us the best mode of proceedure, or train of thought, leading to a proper valuation for these assets—if assets they may all be called? It was my intention to offer some suggestions of my own, but later thoughts prompt me to invite a general discussion through which it is hoped that we may receive some valuable hints. I would suggest that each general classification—drawings, patterns, etc.—be taken up separately.   H. M. NORRIS.

IMITATING OUR INSTRUCTORS—LEVELING WORK ON THE DRILL PRESS.

Editor MACHINERY.

The young man who starts to learn the machinist's trade is sure to imitate the one for whom he works, as we are all inclined to be led more or less. We are all so constituted that we cannot get along to any advantage without the co-operation of our fellow men; therefore the man who is given charge of these young men wants to be a man of some ability, so he can explain why he does his work thus or so. If the boy who stands up to the machine from morning till night, seeing it grinding out the work, when the piece is finished has to go to his foreman to set the machine for the next piece, there is something wrong somewhere, either with the man or the boy. Perhaps the man has not properly explained the setting of the machine to the boy, or the boy has no desire to learn the trade. There are too many boys in our factories to-day who have missed their calling; they would be more profitable to a farmer or some contractor, digging with the pick, thus making room for some young man who has the desire to make a good machinist of himself, and not a machine.

The wrong idea is often taught a young apprentice on the drill press by using a level to true up the work that is to be drilled. This is wrong, for the majority of drill presses are set on wooden floors, and if they are level when put down, will not stay so very long. The writer was watching a man leveling up a piece of work on a drill press. It was a very nice piece, and had to be very accurately drilled. He took the best of care to get a good job from the drill press. After working some time he finally started, and when he had finished with the drill, rose bit and reamer, to his great surprise the hole was out nearly half its diameter. The drill press was blamed for not doing good work, and the man thought he had done his best to get the piece set level; but it was out of true with the machine when

he started his drills. The best and safest way is to try a tram on the drill press table, from the spindle. The tram, it will be understood, should have a taper shank or other means of attaching to the spindle, and is tried at different points of the table by rotating the spindle. JOSIAH DODSON.

DOES NOT AGREE WITH PROF. SWEET—MORE ABOUT THE METRIC SYSTEM.

Editor MACHINERY.

Any impartial reader of Prof. Sweet's paper on the metric system, contained in your issue of December, can easily see that he has overreached himself in his vigorous attack, for while disowning the metric units, he unconsciously turns the full line of argument against the denary scale, or decimal system, of notation in universal use.

When he affirms that barbarous tendencies are to count by decimals, and civilized to count by bisection, he simply turns facts topsy-turvy, for anyone knows that the very first fraction that can be conceived by the uncultivated mind, be he infant or savage, is $\frac{1}{2}$ of anything, but that refinement and education furnish the means of mastering less elementary quantities, until they learn to figure by the units and sub-units of the denary scale in all the processes of pure and applied arithmetic. The metric system may or may not be a good thing, but none can deny that its decimal part entirely fills the bill. If anyone could give out another decimal system of weights and measures fit for all the transactions of modern industry, we might well dispense with the meter, but before that is accomplished this last will hold its own. It is useless to try to convince any thinking mind that decimal division and computation are wrong, in a century when decimal arithmetic, once confined to the infidel Arabs, is at the base of the entire social compact, and in a country where all instruments of precision, from dollars to micrometers, are divided decimally. A. KNUDSEN.

(With the Fred W. Wolf Co., who use the metric system in their shops.)

AN EXPERIMENT IN COMBUSTION.

Editor MACHINERY.

In the December issue W. H. Booth has a valuable and most interesting article concerning fuel consumption and draft. Among many items of a very broad subject, he calls attention to relation between fire thickness and draft power. From the writer's experience he can corroborate Mr. Booth's views, and in connection with draft and fire thickness offers an experiment which may be of interest.

The case in point is that of a hand-fired furnace, discharging through a chimney which has an unusually strong draft. The object of the experiment was to ascertain the percentage by volume of carbon dioxide in the combustion gases with different thickness of fire and power of draft. The writer uses an instrument for determining CO_2 in combustion gases, which indicates continuously, showing the amount at any moment on inspection. In this experiment observations were taken each minute for a period of one hour, these observed amounts being plotted on the diagram shown herewith, and a curve of carbon dioxide drawn. At the beginning of the hour there was a thin fire and 4.0 per cent. CO_2. The draft was .75 of an inch of water. This produced a very rapid combustion, similar to the smithy fire Mr. Booth mentions, and it certainly looked well if one did not take into consideration the enormous excess of air passing through the fire without being used, and which carried with it much heat to the chimney.

The time and duration of the interval at which the furnace was coaled is shown by the short heavy black lines at the bottom of the diagram; these coalings occupied about one-half minute, and it will be observed that the curve begins to drop about one minute after the fire door was opened. This interval of a minute was taken by the gas in passing through the pipe to the instrument. These drops are well defined and show the extra air dilution by way of the furnace doors.

The draft remained at .75 until the twenty-seventh minute, but at each coaling the thickness of fire was increased, resulting in a reduction of the excess of air, and an increase in the proportionate volume of carbon dioxide. This higher standard is illustrated by the gradual step up of the curve. For the first twenty-seven minutes the per cent. of CO_2 is 4.55. At the twenty-seventh minute the damper was adjusted to a draft of .25 of an inch of

water, which continued to the end of the hour. The effect on the curve is shown, beginning at the 28th minute and continuing until the 31st, when its flight was arrested by the opening of the fire door. It will be observed that the reduction of draft power raised the performance of the furnace to a much higher plane of efficiency, and on which it continued. The average per cent. of CO_2 from the time the reduced draft became effective to the end of the hour is 11.88.

It will be observed that when the curve reaches its maximum after coaling that a gradual drop immediately commences, and continues until the next coaling, as shown, for example, from the
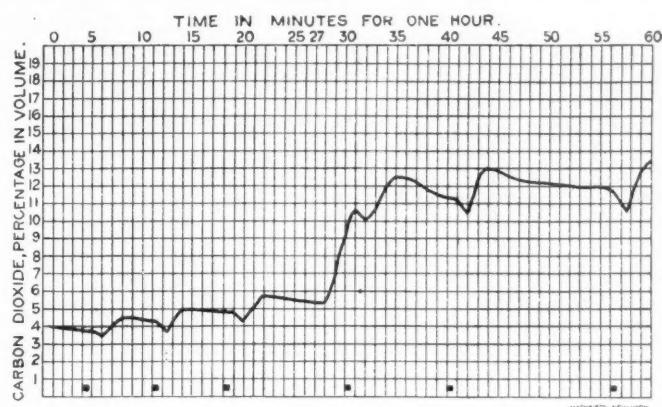
forty-fourth to the fifty-sixth minute. This is particularly so with the curve from the thirty-fifth to the forty-first minute; so much so that as the drop was observed on the instrument the fire was immediately coaled, sooner, in fact, than had been intended. The superiority of this coaling over the previous one is well illustrated by its curve.

If so desired, the curve from one coaling to another may be compared to the diagram from an indicator, as showing the performance in the cylinder of an engine. Thus the curve shows the performance in the furnace.

It is usual to give prominence to what may be called boiler efficiency, and meaning the performance of both boiler and furnace. In this connection the writer would suggest that more attention be given to the furnace itself, alone from the boiler, and the subject of its efficiency, apart from the boiler, be investigated. A. BEMENT.

Chicago, Ill.

TRUING CAST GEAR TEETH—FIXTURE FOR BORING BALL CRANK HANDLES—MILLING ACCURATE SQUARE BARS.

Editor MACHINERY.

Some time ago I saw the following method of finishing the tops of cast gear teeth. It was used upon bevel gears when I saw it, but is capable of other applications where only approximate truth is desired. Fig. 1 shows it in place.
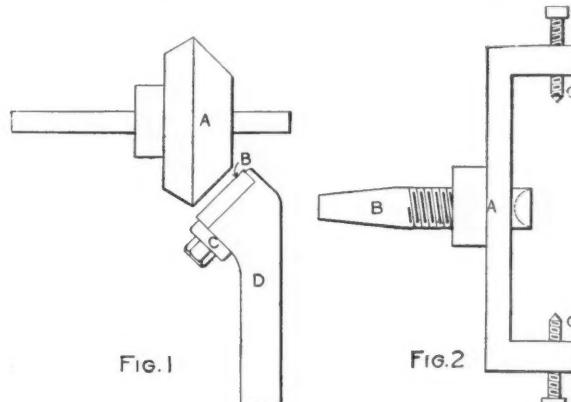
The gear A is mounted on an arbor in a lathe, and the tool B is simply a piece of file clamped by its edges by the strap c in the holder D, which in turn is held in the tool post and forced against the work.

Of course the gear would be trued for boring by the teeth, which would then not run out badly when mounted on the arbor, and there being little work to do, this device is very

rapid. The wear upon the file is slight, and the chips are sometimes of good size.

Another good thing is shown in Fig. 2. It is a chuck for boring ball crank handles and similar work. The figure shows it in all its simplicity.

A is a casting, threaded to fit the shank, B, which may be held in a chuck or fit the taper hole of the lathe head spindle. Upon each end of it is a boss, into which is tapped the pointed screw C. The work is held by these screws entering the centers, which are always in the end of the two balls; and the location of the hole to be bored in the middle ball is secured by turning the screws till the middle ball comes over the shank B, which is cupped on the end. A turn of the casting A screws B against the work, ready for boring or facing. It seems almost unnecessary to say that the screws C should be in line, and their common axes cross the axis of the spindle at right angles.
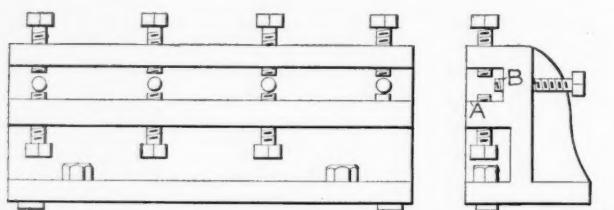
FIG. 3.

A fixture I designed a while ago is shown in Fig. 3. We had a large number of iron castings, twenty or more inches long by three-quarter inch square in cross sections, to mill upon all sides square, out of wind and straight. The problem was to hold them while milling the first two faces, so that they would not spring in clamping, and yet not be troubled with packing each piece. It was solved by carefully planing the surfaces A and B parallel and perpendicular, respectively, to the bottom of the fixture, which rested upon the platen of the milling machine (milling these surfaces in the same machine would have been better, of course). Three holes were drilled and tapped for set screws, as shown, a series each in the top, bottom and back of the portion holding the work, and each pair of upper and lower screws in line with each other, but set staggering with relation to the next pair, so as to give a broader base upon which to hold the work. The lower end screw was omitted, a piece of sheet metal being used in place. The casting to be machined was then clamped upon this piece of sheet metal at the end, and the back screws set out just to bear and bring the outer face right to clean up. The lower screws were then all set up in contact with the work, which was bound down by the upper screws, and one face was milled. That face was next laid upon surface A, all the lower screws being backed out of the way, and held in place by the top and back screws. For the second and third faces only the upper screws were used, the finished faces resting against the bottom and back of the fixture. The fixture was made long enough to take two lengths of castings, and one was replaced while the other was being machined. All screws worked easily with the fingers, and an end mill did the cutting. It was rapid and turned out work of most satisfactory character, though I did fear at first that the points of the screws would be rather an unsecure foundation.

Worcester, Mass.   FREDERICK M. BUSH.

A SET OF ARMATURE PUNCHINGS.

Editor MACHINERY:

I send you a cut of a sample lot of armature discs, all of which were punched out at one stroke of the press. Also a sketch showing how the die was made for the smallest disc shown.

The largest sheet in the lot, in Fig. 1, is 33 inches diameter, with a 22-inch center hole. There are 18 large and 18 small slots in the sheet, to hold the coils of wire used in winding the core. The next sheet is 20 inches diameter, with a 10½-inch center hole, and has 64 slots. The third disc, which is not an armature sheet, but is a punching for the field spools of a fan motor, is 6¼ inches diameter and has a 5½-inch center hole, and eight wings projecting in toward the center, and is one of the most difficult shapes to make a die for, on account of the four small holes shown around the edge. The next sheet is the same as the one shown in the enlarged cut, in Fig. 2, and is 4

inches diameter, and has 37 ¼-inch holes around the edge, which are connected with the outside diameter with slots 1-32 inch wide.

The second cut shows an enlarged view of the sheet, also the die for the same.

When the die for this sheet was first started, the boys used to make picture frames and hall lamps out of the scrap, but it soon got to be an old story with them.

The sketch shows the way the die was made, except that the lower die, which was made of one piece of steel and left soft, and the stripper, which was made in two pieces, and was held together by a ring shrunk on after it was in place on the die, are not indicated as clearly as they should be.

At first, it was thought impossible to make a die that would stand the work, but on account of the large number that were wanted, and the small amount that could be done on a dial feed— which was the method first employed to produce them—it was thought best to give it a trial.

A steel ring was first made having 37 holes (which were drilled by clamping the head from the Brown & Sharpe miller on the table of the drill), and then this was hardened and used as a template for the rest of the work. The lower die was left soft, but the stripper had to be made in two pieces, and held together by a clamp ring. The upper die was made with a hard center ring and a hard center punch, and 37 ¼-inch punches set in around the same. A stripper had to be made which was practically the same as the lower die, and was worked by the pins connected with the knockout plate.

12 IN.

FIG. I.
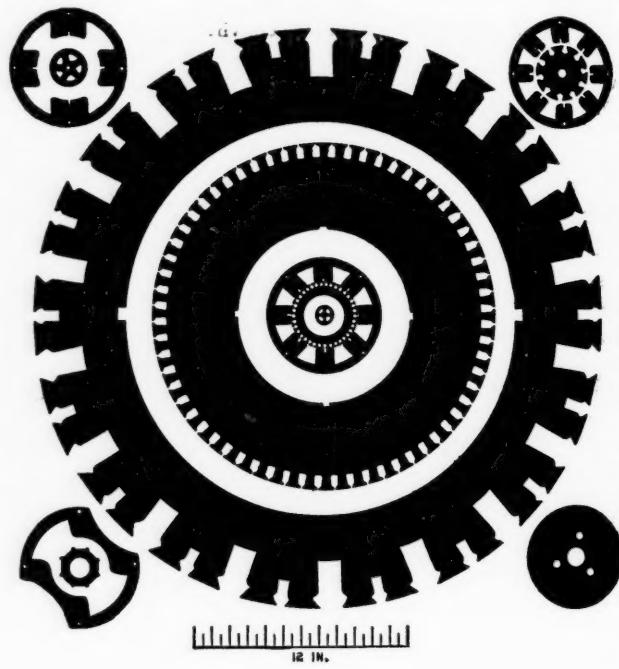
The press in which the die was used was provided with knockouts, which removed the scrap from the punches as the gate went up. I do not know how many sheets were punched out on the die, but I know it was run two or three months, and the average output was 12,000 or 14,000 per day of 21 hours; so it would not be far from 1,000,000 sheets. The dies were suppressed by the use of pilot pins, as shown in the cut.

The die for the 20-inch disc was built up in sections, each die being milled to shape. The great beauty of making a die of this kind is, that it can all be done on a lathe, grinder or milling machine, and very little vise work is needed—that is, if the milling cutters and index plates have been carefully made. There were 64 of these sections, one for each tooth in the sheet.

The steel, which, by the way, was ordered annealed at the mill, was first milled up on centers to nearly the exact shape, and at the proper angle to fit in its place in the die; then the steel was carefully annealed a second time and put through the finishing cutters; these were made very carefully, and kept to the exact size by grinding. After the milling process the dies were cut off, drilled and tapped on the end, and then hardened, the lower end being left soft, as it had to be touched or spotted in the lathe after the die was assembled, to enable the holding down ring to get an equal bearing on them all.

The rings or discs used to hold the dies in their proper places

were of tool steel, left soft, except the center ring or die, and the punch fitting the same, which were hardened and ground to size. After being hardened, the dies were all set in their places in the holder, and the clamp ring having a set screw for each punch was placed around them, the dies held firmly in place while they were ground off on both the ends and the outside diameters.

The shrink ring was then heated to a light straw-color, then shrunk on, clamping the dies firmly in place. After the upper die or punch was thus finished it was entered or forced into the lower die, and while thus entered, was placed on the drill table, and the four holes for the pilot pins—which were of tool steel, hardened and ground—were put in. The object of these pins was to aid in setting the die, as a punch of this kind is
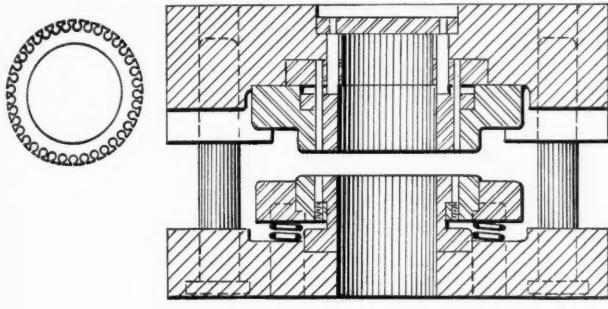

FIG. 2.

apt to enter very hard after being ground, and they also add to the life of the die, as it will run much longer when so fitted. A die of this kind having, say, 64 slots, each 1¼ inches deep, and a center hole of 10½ inches diameter, has about 250 inches of cutting edge; or, in other words, is equal to a plain, round die about 80 inches in diameter. As but little shear can be given to the same, on account of the small diameter, it takes a good press to put it through a sheet of soft steel .040 thick. By the way, I wish that some of your readers, who are expert at figures, would tell us what the required power is. Having seen the upper half of two large presses having 90 inches of cross-section broken entirely off, I estimate it at 300,000 to 400,000 pounds, and I should like to have them check up my figures.

The dies for the rest of the discs shown were made in the same general manner; this one was taken as an example, as it was the most difficult one to make.

There is no armature sheet that I have seen yet but what the dies can be made to punch it at one stroke, provided the stock is not too thick. The advantage of the sheet so punched is too well known to comment upon.

Hoping this may help out some brother die-maker who is lying awake nights, planning out his die work when he ought to be asleep is the wish of   J. L. LUCAS.

* * *

The "American Engineer" calls attention to two methods of keying locomotive piston rods to their crossheads, one of which is objectionable and the other of which embodies an idea that is applicable to stationary as well as to locomotive engine practice, and is one of the minor points that goes to make the difference between good and bad machine design.
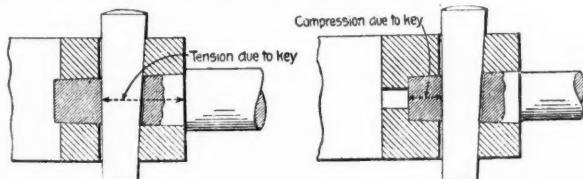
In the left-hand view the key draws the rod in place and produces an initial strain between the shoulder and the key, which necessarily increases the tension in this part of the rod when the engine is in operation. In the second view the rod bottoms in the crosshead and the key forces the rod against the bottom of the hole, instead of drawing it against a shoulder on the rod, as in the previous case. The tendency is, therefore, to compress the rod at the point indicated, and no additional strain is brought upon it by the key that can in any way weaken the rod for the duty that it must perform.

PRACTICAL PROBLEMS.—4.

PROBLEMS 7 AND 8 WITH ANSWERS TO PROBLEMS 5 AND 6.

Problem 7.—To Find the Ratio of Diameters.

The rim A of the disc in Fig. 1 has bearing on its inside periphery the friction wheels B, D and E. D and E are on opposite sides of F, the shaft of the disc A and the distance between their centers is six and one-quarter inches.

The center of the friction wheel C lies in the line joining the cents of B and D.
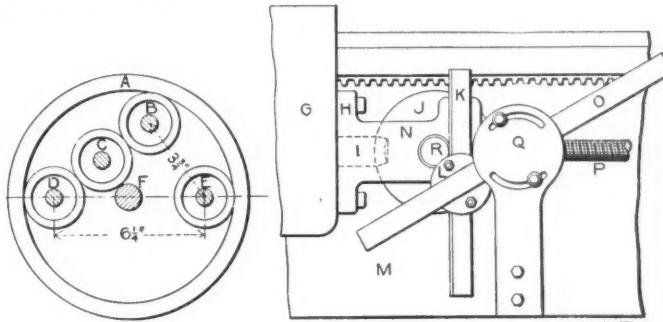
FIG. I.   FIG. 2.

If all the wheels B, C, D and E be of the same diameter and the distance between B and E be three and three-quarter inches, what is the ratio between the outside diameter of D and the inside diameter of A? If after a trial the friction wheels be found unsatisfactory, and it be necessary to provide a positive drive, can the proportions and center distances be kept the same? If so, give the pitch and numbers of teeth.

Problem 8.—A Question in Thread Cutting.

The device shown in Fig. 2 is a modification of a rig which has been proposed for the cutting of unusual or fractional threads, and also for correcting slight errors in the lead screw when the error is uniform. For the latter purpose it would hardly be a success, as it would be more likely to introduce more variation than it would correct, unless very accurately constructed.

In the sketch, G is the carriage apron and M the lathe bed. The usual split nut and locking handle are removed and the bracket H bolted to the edge of the apron, as shown. This bracket forms a support for the bevel gears I and J, and also for the sliding rack K.

The gear I, shown by dotted lines, is extended to the left and forms a revolving nut on the lead screw P. Mounted on the shaft of J is the pinion R, which is engaged with the rack K. This rack is fitted in a grove in H and can slide up and down, and thus transmit motion through R and J to the revolving nut I. The part Q, which is solidly bolted to the lathe bed, forms a support to bar O, and is provided with slotted holes, so that O can be shifted through an angle of something more than 60 degrees. Fastened to K is the piece L, which can freely slide on the bar O. If the nut I remain stationary while the lead screw revolves, the pitch of the thread can be calculated in the usual way, with whatever gears used, but if connected, as shown in the sketch, the result will be different.

Gear J has 64 teeth.
Gear I has 16 teeth.
Gear R has 14 teeth, 8 pitch.

The screw P has a lead of 4 to the inch, right hand and turns in the same direction as the lathe spindle.

The inclination of the bar O is 5.4978 inches vertical distance in a horizontal distance of 9 inches.

With a gear of 24 teeth on the stud and one of 48 teeth on the screw, what lead of screw will be cut? It will be seen that with this attachment the incommensurable thread 7.071-|- to the inch required for the screw in the chuck problem of the September number can be easily produced.

Answers to Problems 5 and 6.

Up to the time of this writing the following interesting solutions to the January problems have been received and are here presented in a slightly condensed form.

The solutions to No. 5 have been arranged so that they all refer to the same sketch (Fig. 3).

The solution of problem 5, by Mr. Elmer G. Eberhardt, in

which he uses the principles of right-angled trianges, will be found simple and easily understood, and is the method that the writer expected would be used by all, but two of the solutions are by the principles of trigonometry.

The value of these will be seen that they are applicable to the position of the crank as given in the problem, and also any other angular position, while the first solution fails in any but the one given.

Mr. Eberhardt's solution follows: Problem 5—Let us first make a sketch as Joe Thompson found it (Fig. 3). B is the crank
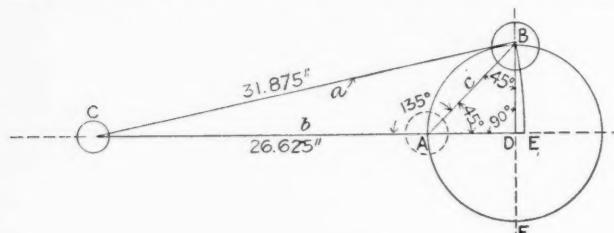
FIG. 3.

pin, C B the connecting rod, and C the wrist pin. A D = ½ stroke = x.

Now as B is at the top quarter, we have a right triangle, B D C, hence

$$B C^2 = \overline{B D}^2 + \overline{C D}^2 \ldots\ldots\ldots\ldots\ldots (1.)$$

Now B C = 31.875, B D = x and C D = 26.625 + x, since the sum of the diameters of the crank and wrist pins equals 5¼ inches, and one-half of this plus 24 inches equals 26.625.

Hence putting these values in the above equation (1) we have

$$X^2 + (X + 26.625)^2 = 31.875^2$$
$$X^2 + 26.625 X = 153.5625$$
$$X = 4.875 = 4\tfrac{7}{8} \text{ inches.}$$

Therefore, the stroke, or 2 x = 9¾ inches. Now if we swing the rod down to E without disturbing the crosshead we see that the distance D E is the amount that the crosshead is from the center of the stroke. To find this we subtract A C + A D from C E, or 31.875 — (4¾ + 26.625) = ⅜ inch, distance from center of wrist pin to center of the stroke.

Mr. Eberhardt also sends a correct answer to problem 6, as does Mr. E. J. Mason, of Columbia, Mo., whose solutions follow:

Problem 6.—This problem can be considered in two ways; (1) consider the system as a lever D F (Fig. 4), whose fulcrum F is free to move along the floor. It is evident then that a pull applied at E will draw the system to the right. The distance which the system moves is found by the proportion 6 : ½ = 1½ : x, in which x = 18 ft.

(2) Consider wheel C to roll 1 foot toward the right. Then B will turn through two-thirds of a foot, and will wind up two-thirds of a foot of cord. So that in order to keep the cord tight A must move one-third of a foot toward the right, and as the system moves through one foot while A moves one-third of a foot, it will traverse 18 feet to 6 feet of A.
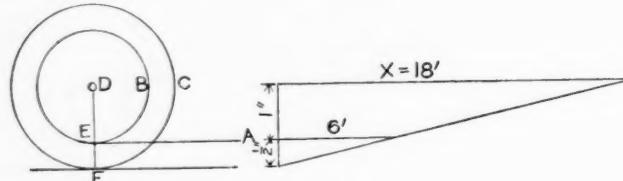
FIG. 4

The following solution is by Mr. Darcy E. Lewellen, of Columbus, Ind.

Problem 6.—Since angle B D C = 90 degrees, and since in any triangle the sines of the angles are proportional to the sides opposite, and since sides D A and D B are equal, the opposite angles must be equal. Since the sum of the angles of any triangle equal 2 right angles,

180 degrees — 90 degrees = 90 degrees.

90 degrees ÷ 2 = 45 degrees = angles A B D and D A B.

Now, since the adjoining angles formed by the intersection of two straight lines are equal to 2 right angles,

Angle C A B = 180 degrees — 45 degrees = 135 degrees.

31.875 : 26.625 :: sin 135 degrees : sin C B A

Sin 135 degrees = .70711

26.625 × .70711 = 18.8268

18.8268 ÷ 31.875 = .59064 = sin C B A

Sin .59064 = 36° 12′ = Angle C B A

135 degrees + 36 degrees 12 minutes = 171 degrees 12 minutes.

180 degrees — 171 degrees 12 minutes = 8 degrees 48 minutes = Angle B C A.

Sin C B A : sin B C A :: 26.625 : side A B.

Sin 8 degrees 48 minutes = .15299.

.59064 : .15299 :: 26.625 : A B

.15299 × 26.625 = 4.07335.

4.07335 ÷ .59064 = 6.8965 + length A B

We then have the right-angled triangle A B D, with the length of one side and all the angles.

Sin A D B : sin D A B :: 6.8965 : B D

Sin 90 degrees = 1

Sin 45 degrees = .70711

1 : .70711 :: 6.8965 : B D

.70711 × 6.8965 = 4.87658 + 4.87658 ÷ 1 = 4.87658 = 4⅞ inches = B D = ½ stroke

4⅞ inches × 2 = 9¾ inches = stroke of piston.

If the connecting rod had not been removed and the crank turned to its back center, the distance from A to C would have been 31.875 inches; therefore, at C the crosshead must have been displaced from its farthest backward position, the difference between 31.875 and 26.625 = 5.25 — 4.875 = ⅜ inch, forward of its position at half stroke.

For lack of space it has been necessary to abridge somewhat the solution of B. D. W., who was too modest to send his name and address. He has no need to feel ashamed of it, as the readers can judge:

Problem 6.—The circle A B F represents the path of the crank pin during a revolution, the diameter is unknown, but it must be equal to the stroke of the engine. The engine was disconnected, as shown in the sketch (Fig. 3), with the crank pin on the top quarter; then the crank was turned to the center next the cylinder and occupied the position shown by the dotted circle A.

Angle A D B = 90 degrees, sides A D and B D are equal; hence, angles A B D and B A D are equal.

Length of the connecting rod B C = 31.875 inches. Joe finds the distance between the crank pin A and wrist pin C to be 24 inches. Then in this position the centers of the pins are

$$24 + \frac{2\tfrac{1}{4} + 3}{2} \; 26\tfrac{5}{8} \text{ inches} = A C.$$

In the triangle A B D, angle B A D = 45 degrees; hence, in the triangle A B C angle A must equal 135 degrees. We now have in triangle A B C all the factors necessary to find the missing quantities in the triangle, viz., angle A B C, angle B C A and side A B. To find A B we have two sides and an angle opposite one of them.

We find angle B by the proportion:

Side a : sin 135 degrees :: side b : sin B.

(Arith. comp.) 31.875 = 8.4965498

Log sin 135 degrees = 9.8494850

Log 26.626 = 1.4252896

Log sin B = 9.7713244 = 36° 12′ 06″

Then angle C = 180 degrees — (36° 12′ 16″ + 135°) = 8° 47′ 54″. = For side c we have the proportion:

Sin A : side a :: sin C : side c.

(Arith. comp.) Log sin 135 degrees = 0.1505150

Log. 31.875 = 1.5034502

Log sin. 8° 47′ 54″ = 9.1845696

.8385348 =

log 6.895 = side A B.

.8385348 — (log cos 45 degrees = 9.849485) = .6880198 = log 4.875 side A D

A D = radius of circle A B F = ½ stroke of engine.

4.875 × 2 = 9¾ full stroke.

B. D. W. gives the displacement of the wrist pin from the half-stroke position as ⅜ inch, by a continuation of the above.

Mr. N. J. Smith, of Saybrook Point, Conn., sent in correct answers to problems 3 and 4, but too late for publication last month, and as the solutions given covered the ground thoroughly they will not be repeated.   FRED E. ROGERS.

"WHAT SHALL WE DO WITH OUR BOYS?"

SOUND ADVICE FOR THE YOUNGER READERS, FROM ONE WHO OUGHT TO KNOW.

John J. Grant.

Several years ago, while listening to a lecture by ·Mrs. Mary A. Livermore on "What Shall We Do With Our Girls," I wondered why some one did not give the boys a chance, or, rather, why some one did not come forward with something of the same sort for the benefit of the coming man.

"What shall we do with our boys" has probably been dis-cussed in millions of households, and probably will be as long as there are boys to worry over.

So many young men are steered into the wrong channel every year by those who think they are capable of giving advice to boys and young men whom they often have met but once or twice. No person should ever advise parents what to do with their boys, unless he is thoroughly familiar with all the boy's traits and peculiarities. Many a poor preacher or doctor would have made a good, perhaps, brilliant mechanic, and vice versa, had not some kindly disposed person advised him what calling to pursue, without having a particle of knowledge of the boy's ability in that direction.

Too many of the best learning years of a boy's life must be given to thoroughly master any business or profession to aban-don it, if, after learning it, he finds he is better adapted to some other calling, although I advise such a course, even though he has given several years to perfecting himself in the wrong trade.

As we have here to deal more especially with boys who are expected to take up a mechanical training, let us see what we should do to find out if they are of a suitable temperament to become successful mechanics. Don't imagine for an instant that I mean by a successful mechanic one who becomes the owner of a big establishment, or a great inventor; all cannot be owners, superintendents, or even foremen, and I would far rather be a good journeyman than a poor director.

I will reverse the old saying, and remark here that "there is always room at the bottom." How many manufacturers will tell you that even in times of business depression it is hard to get good mechanics. I speak from actual experience, as personally I have had the hiring of thousands of men. Don't think I decry ambition in a boy to be all he can, or is capable of being; but, again, many a fine workman at the bench has been spoiled by being made foreman, a position in which he is never a success.

Don't crowd a boy into any business unless he is suited to it, and, in a great measure, he should be the one to determine what business, trade or profession he should follow. If a boy has mechanical ability, he is pretty sure to show it very early in life, as a general thing he would much rather "tinker" than play ball or other boyish games; he is never so happy as when mak-ing something, and such a boy should be encouraged in his me-chanical fancies.

I suppose there are many people who do not believe in phre-nology, but an examination of a boy's head by a good phrenolo-gist will determine his natural mechanical ability, even when quite young.

Having come to the conclusion that the boy is adapted for a mechanic, comes the question, "What shall we do with our boys?" Shall they receive a technical education first, and then be placed in a shop, or, shall they give him a good common school course, then put to a trade and serve a regular appren-ticeship, afterward taking a course in a scientific institution? I believe nine superintendents and managers out of every ten will agree with me that the latter course is far the best. It is too bad to be obliged to say it, but one-half that a young man has learned of shop practice and the manipulation of tools in manual train-ing schools has to be unlearned before he is of any real value in the shop. In institutes of learning, or rather I should put it, places devoted to teaching alone. (for what is a common job-bing machine shop but an institution for learning), a boy is taught that there is but one angle for the cutting edge of a tool and but one angle at which it must be set. In nine out of ten of the manual training schools, a boy is not taught that time is of any consequence. What is the result when he finds employment in a shop where he has to hustle to keep up with a two year old apprentice, and watches him grind a tool at an angle which he has been taught is entirely wrong? He begins to air his su-

perior knowledge to the shop two year old, and says, "Your tools are not right and won't work." The boy answers him in the same manner that the man in jail did the pettifogging law-yer, who told him they could not put him in for that; but he says, "I am in," and boy says, "It does work, and I am pro-ducing twice the work you are."

Again, a boy educated in the shop learns many things which it is not possible to learn in a technical school, no matter how well they are equipped with tools, for the reason that there is constantly cropping up in the machine shop, pieces to be ma-chined that you can swear by, because their like was never seen on earth before, and some way must be devised to finish them. Such things a machine shop "cub" sees every day, and if he is bright he notices the way the difficulties are overcome and don't forget it; when boys are taught these things before their advent into the "boss incubators," as the shop cub dubs the technical school, it is hard work for the instructor to convince him that he has been taught wrong, and, according to the young man's temperament, he will either argue with the instructor, or quietly wink his eye, and take that which practical experience has taught him is best, and discard the rest. Now, I do not want any reader of this article to think for a moment that I am not a thorough believer in education, and for the mechanic a good technical course. I simply want to say that in nearly every case I have known where a boy has had such an education before his shop experience he has come out second best in an encounter with a shop-taught boy who has subsequently passed through the same course. Next comes the kind of a shop in which to ap-prentice a boy.

The best mechanics we have to-day learned their trade in a humble country jobbing machine shop, where it requires brains to be successful; where, as "Chordal" says, "A man is often compelled to bore out a cylinder with a grate bar." Such a place is where a boy learns to think for himself, and where he is gen-erally allowed to go ahead with slight instructions and develop makeshifts, and if he is obliged to, can turn a main line shaft without a lathe, which the writer has seen done.

It is such shops that bring out the latent talent in a boy and fit him, should he ever be called upon, to superintend large establishments. I have noticed in conversation with many men who are at the head of large shops, either as superintendents, or at the head of the draughting departments, that their early knowl-edge of mechanics was obtained in the small shops, where the work was of a varied character that would not bear the cost of jigs or fixtures.

There is a growing tendency in this country, as has been the practice for many years in England, to apprentice a boy to one branch of the trade. This is all right for the manufacturer, and will generally produce a man who is more skilled in one partic-ular branch, but there will soon be left but a small number of the good old-fashioned all-around mechanics. It would seem from the foregoing that "What we should do with our boys" is this: First determine whether they are fitted to be mechanics by nature and encouragement; second, give them a good com-mon school education; third, apprentice them to a shop not too well equipped with the modern tools and labor-saving devices, but managed by a man with brains; fourth, if possible, give them a good technical education, and then leave them to work out their own position in the chosen vocation, remembering that the rank and file of the army of mechanics are of as much im-portance as the officers in command.

* * *

A GOOD RECORD.

While looking through the plant of the Erie Forge Co., Erie, Pa., the snapping of a lathe tool attracted my attention. The feed was 4 to the inch, and the depth of the cut sufficient to com-pletely clean up the rough 20-inch forged shaft in good shape for a distance of 10 feet $4\frac{1}{2}$ inches in length, leaving a surface plenty good enough for a roughing cut. Thus more than 54 square feet were surfaced with one tool at one setting. This was so commonplace as to excite no comment in that shop, but there are so many cases where a turning tool is ground every 3 or 4 feet on a shaft about 6 inches in diameter that this example is worth calling attention to.   Milo.

* * *

Emery wheels are time savers and are cheaper than files. Adapt the wheels to your work, distribute them around the shop and keep them in good order.

HARDENING AND ANNEALING.

PRACTICAL POINTS PRESENTED BY EXPERIENCED MEN AT THE LAST MEETING OF THE RAILROAD MASTER BLACKSMITHS' ASSOCIATION.

The report has reached us of the sixth annual convention of the National Railroad Master Blacksmiths' Association, of which A. L. Woodworth, Lima, Ohio, is secretary. It is a pamphlet of over 150 pages, composed in part of abstracts of the papers presented and of the reports of committees upon practical blacksmithing subjects. There was some discussion upon hardening and annealing steel, from which we extract a few notes that will be of interest.

Oil vs. Water.

Mr. George F. Hinkens offered a few words relative to hardening steel with a soft center. To immerse steel in cold water and allow it to remain there no longer than is sufficient for hardening the outside to a proper depth requires experience gained from observation, for the toolsmith must be guided entirely by the bulk of the article to be hardened and a hissing sound that the steel produces in the water while cooling.

This certain sound, and at times a tremor, indicates the effect to be produced. As soon as he discovers the effect, the steel should be immediately taken out of the water and immersed in oil.

The oil will prevent the outside from becoming soft and will keep the center soft. This in a measure applies to articles of small dimensions, large pieces being hardened only to a certain depth from the surface by reason that the heat in the interior cannot be extracted quick enough. In my opinion the immersion in oil is beneficial for the reason that it will allow the particles a longer time to arrange themselves than if cooled in water. In order to substantiate this theory let us take a thin piece and cool it in cold water, and we find that it will crack or warp. Now, the same article cooled in oil will not crack and will warp only slightly. The reason is obvious. Oil is a slow conductor of heat and allows the particles to assume their normal state in a manner to which they are naturally disposed; hence, the first operation in water will take care of the exterior of the steel, the second, the oil takes care of the interior and prevents the outside from cracking, by giving the steel time to cool uniformly.

Annealing Cast Steel.

Mr. H. H. Miner, of the Crescent Steel Co., made a contribution upon annealing cast steel, from which we quote the following:

Clean iron filings have been used for annealing by packing the steel between layers—in the case of small dies—protecting the face of the steel by some coating or other, such as paste, black lead, etc., and then heating in the box for two or three hours. This plan, however, was not satisfactory in the case of some very fine die steel, upon which delicate lines were engraved. A prominent writer says: "Of all the abomination in the annealing line, those in which layer after layer of steel alternate with broken charcoal, or other packing, until huge boxes of the doomed material are stored away in a furnace to be heated, are among the worst. By this plan outside layers are heated sufficiently hot before the steel in the center of boxes is changed from black."

You will see from this that there is a variety of opinion as to the value of this manner of annealing. I have had no direct experience myself with this, but it seems to me as though the plan were rather a tedious one to go into, when steel can be annealed just as thoroughly and with less expense. Probably more steel is annealed in a steel mill than in any other place in the country, and certainly thoroughness should be and is the first essential. What is good practice in a steel mill should be good practice with the steel user. In fine annealing, such as with our drill rods, we must have perfection, and protection from oxidation and the decarbonization of the surface. The plan to accomplish this is rather elaborate and would probably not answer for the average consumer.

However, the following suggestions of a writer modify the plan used on drill rods, and besides, not being expensive, is adapted to the average consumer. Take a pipe of convenient size with one end welded solid; have a cap made to screw loosely on the open end. To charge this pipe, first throw a handful of resin in the bottom, then put in the steel to be annealed, then throw

another handful of resin near the open cap end, then screw on the cap. Now put the pipe in the furnace for heating; the resin will be volatilized at once, and fill the pipe with carbon or hydrocarbon gases, which will unite with the air long before the steel is hot enough to be attacked. This gas will cause an outward pressure and may be seen burning as it leaks through the joint at the cap. This prevents air coming in contact with the steel and consequently there is no scale formed on the steel. It reduces the scale on the surface of the pieces, leaving them a dark gray color, and covered with fine carbon or soot. A little experience will teach how long the pipe should remain in the fire to heat the contents properly. The whole should be removed as soon as heated through, and then buried in dry ashes until cold.

To those steel workers who do not care to go to the trouble of the above plan, a good way to anneal steel is to heat on a clean coke fire, not any hotter than a nice even red; heat slowly, heat through to the center, and bury the steel in dry lime, charcoal or ashes. Steel heated this way will cut very soft. If the steel is heated too hot it will probably be hard and gritty on the surface, owing to the heavy scale formed. If heated too long, it will cut stringy.

General Notes upon Hardening.

A few notes were read by F. C. Law upon hardening and annealing steel, gleaned from several years of study and experience. He attached great importance to using a heat that is within the conducting power of the steel. The moment a bar of steel is placed in the furnace it absorbs heat and heat is conducted to the center of the bar. If the furnace is so hot that the outside of the bar attains the refining heat before it can conduct enough heat to its center to bring the bar to a uniform temperature, we find that after quenching there are a number of hard spots and the depth of hardness is only about half of that in the properly heated bar. If we use a heat which is within the conducting limit of the bar, however, we find that when the bar attains the refining heat it has the same temperature throughout and the condition of the grain is uniform.

If we use a gas furnace, we can control the heat to a nicety and I have found that the approximate temperature can be determined by using a small copper box 1x3x1 inch deep, partly filled with granulated aluminum, 98 per cent. pure, placing it in the furnace, and bringing the furnace to a temperature where the aluminum becomes pasty, so that it can be rolled up into a ball. If we maintain such a temperature (about 615 degrees C.), we find that it is within the limits of the heat conducting power of steel containing from .80 to 1.50 per cent. of carbon. For high alloys a lower heat must be used, about 600 degrees C., and for steel low in carbon the aluminum should be in the molten state.

The carefully trained eye will check the temperature of the furnace after the first day's run with the aluminum in the furnace. When the refining heat is attained you will notice very prominent waves playing over the bar. Doubtless every smith who uses a furnace has noticed the waves, but has taken them for air currents. Such, however, is not the case. When the heat is about half complete the waves combine. When the wave disappears it is an indication that the heat is completed. The temperature of the bar is then uniform throughout, hence the color of the bar is also uniform, and if quenched under these conditions we obtain the ideal condition of steel in the hardened state. The color of the surface of the bar after quenching will be an even black, and if fractured the fracture will be strong and very fine grained, with a satin, sappy appearance.

Steel thus treated will never crack. When we quench from a higher temperature we do not retain the solid black surface; little gray spots are then distributed over the surface which increase in size as we increase the temperature, until we have eliminated the black surface altogether, and a solid gray surface is presented. The fracture under such conditions is short, very dry and granular.

It will not be out of place to state here that a high heat can be safely used for forging, provided that the smith works heavy at the start, easing up on the passes as the temperature falls. The proper forging heat is also the refining heat; and just as much care should be exercised in heating for forging as in heating for hardening.

It is just as important that the bar for forging should attain a temperature as uniform as the bar for hardening. In forging a bar which has been heated uniformly, the metal flows freely without meeting any obstructions; but if we were to forge a bar,

which, if quenched, would reveal the soft spots, the soft spots in the hardening bar will be harder in the heated condition, because the refining heat has not been completed in these spots, and therefore they are not in the same plastic condition as the balance of the heated bar.

Notes upon Annealing.

Slow heating and slow cooling are the two essential points in annealing, because they allow the steel to expand and contract uniformly. Slow cooling allows the grain to assume a different structure, and steel thus treated will show a marked change in its condition, the grain being closer, and as a rule with more lustre than before annealing.

The pipe or box is generally used. which should be as nearly air tight as possible, to prevent the piece from scaling when cooling. This is about all that can be said in praise of the method, because we cannot see the condition of the articles; they may be too high in the heat or not high enough. Again, we may take a dozen pieces from the same bar, put them in the furnace at the same time, and we find that they will not complete the heat at the same time; they may vary three or four minutes. notwithstanding that the heat is constant and of uniform strength. Hence, we can not attain uniformity in box annealing.

Careful experiments have proven that the best method of annealing is to use a heat which will just complete the refining heat, and when the heat has been completed bury the article in fine, dry sawdust. No steel will give or cause trouble which has been kept within the refining range in heating, either for annealing or hardening.

* * *

POSITIVE DRIVING CHUCK.

Under modern conditions of exact lathe and milling work, the chuck which holds and drives the drill, boring tool or reamer, should be a thoroughly workmanlike and durable tool. This is especially important for all uses of chucks on drill presses and turret machines for turning out large orders and true-to-gauge work.
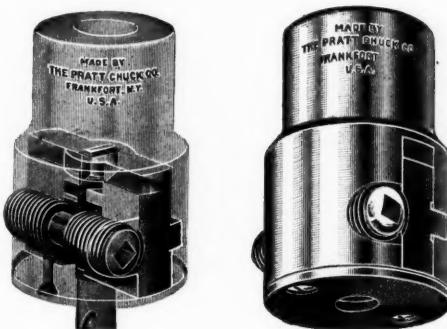

Fig. 1 is a general view and Fig. 2 a clear representation of the working parts of a chuck designed to meet such conditions The distinctive feature of the tool is an equalizing driver which takes the flattened shank-end of the drill or other working tool. This driver consists of a cross-bar pierced with a rectangular socket-hole, indicated in both figures, lying in the base of the chuck. By the use of this device the jaws of the chuck have only to hold the work tool in perfect alignment, and are relieved of the twisting strain of driving the tool as well. The end of the tool-shank need not be accurately or centrally flattened as the body of the chuck is hollowed out to a sufficiently loose fit about the driver to allow any such an imperfect shank to find the socket and be positively driven by it. As it is impossible for a tool to slip, the jaws need be tightened only enough to allow the tool to float—a handy feature when the chuck is in use on worn lathes where the turret holes are out of line. Perfect work on a finishing cut, it will be readily appreciated, can thus be done on an old and imperfect machine. The use of the positive driver here described is facilitated by the fact that leading drill makers furnish drills and reamers with properly flattened shank-ends, if desired, without extra expense over ordinary round shanks. Taper shank drills with flattened ends are perfectly held by the driver, the jaws bearing for alignment grip on a special taper steel split sleeve made for these chucks. The chucks are made in five sizes, adapted for cranks from the smallest up to 2 inches in diameter, by the Pratt Chuck Co.. Frankfort, N. Y.

EPICYCLIC BACK GEARS.

An epicyclic back-gear, as applied to an English drill press, made by Messrs. Humpage, Jacques and Pedersen, Ashton-gate, Bristol, was illustrated in a recent issue of the London "Engineer," and while it is less simple and would probably be more noisy than some American gears on this plan, in which spur gears are used instead of bevel gears, it at least forms an interesting example of mechanism. Referring to Fig. 1, the cone pulley is made with an internal boss A, to which is fastened the first driving pinion B. A double-armed cross-head, which is free to rotate on the spindle, carries on each arm a pair of wheels, D and E, which are fastened together and rotate as one. The wheel F is keyed to the spindle, and wheel G is provided with an extended boss which fits in the split-bearing H, and can be gripped and prevented from turning by tightening the handle J. The second pair of wheels, D^1, E^1. are carried on the crosshead arm at an angle of 180 degrees, and cannot be seen in the half-section drawing, but are shown in Fig. 2.


FIG. I.
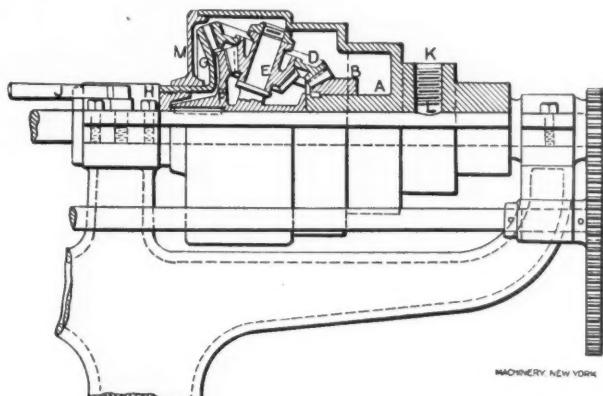
The action of the gearing is as follows: The wheel B gears with D, which in turn gears with G, and the wheel E gears with F. On turning A, the wheel B drives D, and as G is fixed and cannot revolve, the wheels D E and the crosshead C are caused to rotate bodily around the mandril, at the same time the wheels D E run on the arms of the crosshead C are caused to rotate bodily around the mandril, at the same time the wheels D E run on the arms of the crosshead. This compound movement of D E of rotation on their own axis, and also bodily around the spindle, causes the wheel F to be driven in the same direction at a speed according to the ratio of the gearing.
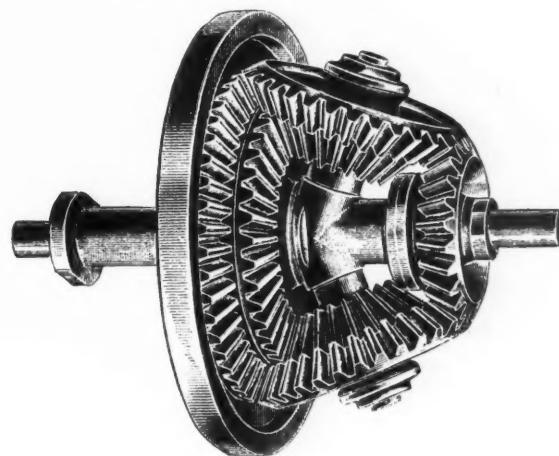

FIG. 2.

When it is desired to run with the back gears out the screw K is tightened against the mandril through the gun-metal pad L and the handle J is slackened. The whole gear is then locked together, and turns without teeth being exchanged. The end plate M forms an oil-tight joint, and all the wheels run in a bath of oil. The number of teeth in the gear in question are:

|	
B = 12	F = 34
D = 40	G = 46
E = 16	

Ratio, 10.53 to 1.

HOW AND WHY.

A DEPARTMENT INTENDED TO CONTAIN CORRECT ANSWERS TO PRACTICAL QUESTIONS OF GENERAL INTEREST.

Give all details and name and address. The latter are for our own convenience and will not be published.

[The questions for this number were answered by Mr. A. H. Eldredge, Instructor in Mechanical Engineering, Cornell University.]

57. W writes: Will you kindly answer the following in your "How and Why" Column. We have a compressor that is used to compress ammonia gas in a refrigerating plant. The diameter of pump is 12 inches and stroke 12 inches. The pressure pumped against is 200 lbs. gauge and the back average suction pressure 15 lbs. gauge. I wish to know the distance the piston has traveled from dead center when the compressor valves are first opened. Also, the mean pressure throughout the stroke. Please give a rule for finding the same.

A. The following method of procedure, though not scientifically correct, will, however, approach as closely to the actual conditions as any more refined and difficult solution. A piece of cross section paper will facilitate matters greatly. Along the bottom of the paper lay off the stroke of the engine to scale in inches, and subdivide each inch into five equal parts. At the side of the paper lay off the scale of pressure above the atmospheric line, letting each small division represent 5 pounds. Then we can draw the back pressure line of 15 lbs. three divisions above the atmospheric line, and assuming the absolute pressure as 15 lbs. below the atmospheric pressure, the absolute line of pressure will come three divisions below the atmospheric line. Assume the clearance to be one-fifth of an inch, and lay off the clearance line c c′ = one small division of a scale. We know the absolute

$$6 = p = \frac{366}{31} = 11.8$$

$$2 = p = \frac{366}{11} = 33.3$$

$$1 = p = \frac{366}{6} = 61$$

Draw the curve through these points. The point where it cuts the 200 lbs. pressure line is where the valve will open, though it might come a trifle higher, due to any friction or weight of the valve. By counting the divisions it will be found that the valve will open 53 divisions from beginning of compression, or $\frac{53}{60} = 88.3$ per cent. from end of stroke. The compression curve can be started from any point as x and plotted the same way.

To find the mean pressure divide the card into 10 equal parts and erect a perpendicular through the center of these parts. Lay off on a strip of paper the consecutive lengths of these parts above the back pressure line, as shown in Fig. 2, and divide the total length by 10; this gives the mean height of the card. The mean height by the scale of spring equals mean pressure. For figuring the horse power see "Steam Engine Tests" in October MACHINERY, 1898.

Fig. 2.

Fig. 1.

Fig. 3.
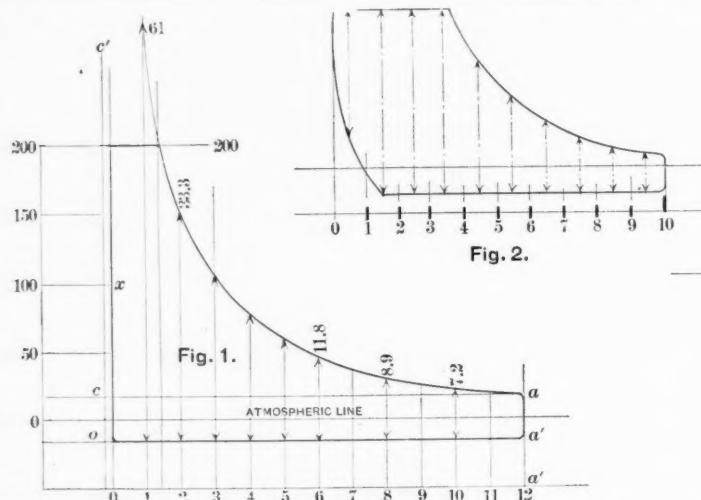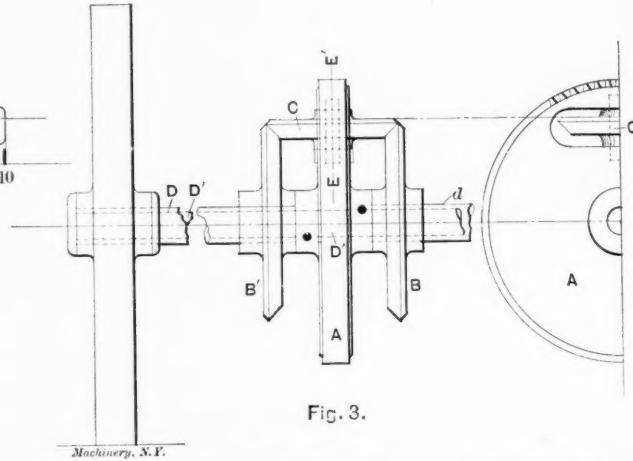
Machinery, N.Y.

pressure at the beginning of compression to be $15 + 15 = 30$ lbs. and the total volume through which the gas has expanded can be represented by c a′. Now the product of the volume times the pressure is a constant quantity for hyperbolic compression or expansion, and is as close to the actual condition as we need to consider.

Let pressure = p
Let volume = V
Then for point (a) we have

$$p \times V = \text{const.} \dots\dots\dots\dots\dots\dots(I)$$

The number of small divisions to (a) are 61, and from (a) to (a′) = 6. So we have (I)

$$61 \times 6 = 366 = \text{constant} = (C)$$

In order to find any point in the expansion curve, say, corresponding to division (10). There are 51 divisions to 10, and the pressure at that point will be

$$p = \frac{\text{const}}{V} \dots\dots\dots\dots\dots\dots\dots(II)$$

$$= \frac{366}{51} = 7.17$$

Count up 7.2 division above oa′, and we have a point in the curve.

Likewise at divisions 8, 7, 6, etc.

$$8 = p = \frac{366}{41} = 8.9$$

58. F. H. G. asks: How much water at a temperature of 55 degrees F. would be required to reduce the temperature of water at 190 degrees F. to 140 degrees F.?

A. The amount of water to be cooled not being stated, we will assume that only one pound is to be cooled, and our results can be multiplied by any number (x) which will give the amount required to cool (x) pounds. For the least amount of cooling matter necessary assume the final temperature of the cooling water to be 140 degrees. The amount of heat (H) which a body will take up equals its specific heat (S) by its weight (W) times its difference of temperature (D), or

$$H = S \times W \times D \dots\dots\dots\dots\dots\dots\dots(I)$$

Now the specific heat of water is (1) at temperature 62 degrees F., and is so nearly constant for the temperatures taken that we may use this value without sensible error.

The total heat (B. T. U.) in a pound of water at 190 degrees F. equals 190.64, and at 140 degrees F. equals 140.24.

Had the specific heat remained constant the total heat in one pound of water at 190 degrees F. would be 190 B. T. U., so that the change in the specific heat has increased the value at a temperature of 190 degrees by about .3 of 1 per cent.

The amount of heat to be absorbed equals $190.64 - 140.24 = 50.4$ B. T. U.

From (I) we have

$$50.4 = 1 \times W. \times (140-55)$$

Or,
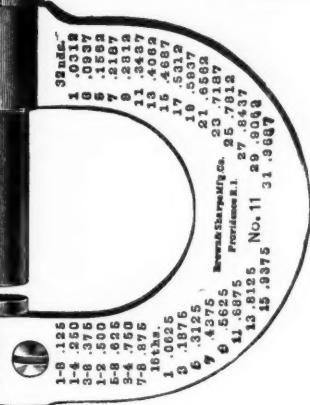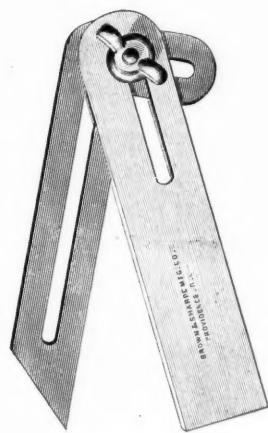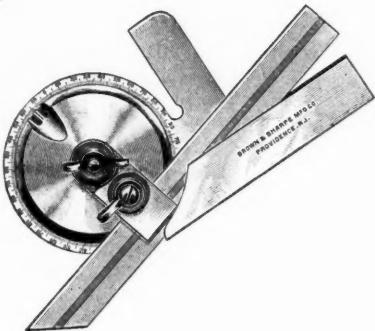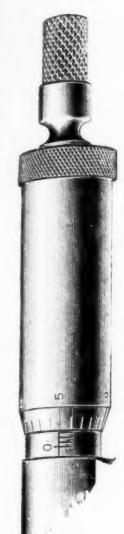
$$W = \frac{50.4}{85} = .593$$

or .6 pounds of water with a raise of 85 degrees temperature will cool down 1 pound of water through 50 degrees fall of temperature.

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59. R. B. asks: First, With what force will a 33,000-lb. steel ball strike falling 50 ft? Second, With what force can an ordinary man strike with a 30-lb sledge hammer? Third, What force will a 1,500-lb. drop steam hammer strike; diameter of steam cylinder 12 in. and stroke 3 ft., steam pressure 150 lbs? Fourth, What load will it take to break a cast-steel shaft 22 in. diameter, distance between supports 6 ft?

A. The above are all difficult questions to answer, and the first three can only be answered when we know the velocity at which the body is moving at the instant of striking and the time required to bring the body to rest. Or, we can find approximately the force of the blow if we know the capacity of the moving piece to do work and divide this capacity by the distance through which it moves whatever obstruction brings it to rest.

Let F = force of blow in lbs.
h = height of fall in feet.
W = moving weight in lbs.
R = distance through which the resistance acts in feet.

Then

$$F = \frac{W h}{R} \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots(I)$$

In order to find the force of the blow it is absolutely necessary to know R. Suppose, for instance, the steel ball strikes a steel bar that has absolutely no give. Then

$$F = \frac{33,000 \times 50}{0} = \text{infinity.}$$

The weight would strike an infinitely hard blow, and would itself be crushed. Again, the ball could strike a spring that would bring it to rest through so great a distance that the force would approach zero.

Assume R = ½ inch = $\frac{.5}{12}$ ft.

$$F = \frac{33,000 \times 50 \times 12}{.5} = 39,600,000 \text{ lbs.}$$

2. What has been said in case of the ball holds true in questions two and three. Assume the man to be pile driving, and that each of his last blows moved the pile ¼ inch. The average man will expend his force raising the hammer, and will add little or nothing to its natural velocity due the force of gravity. Let the distance through which the hammer falls equal 4 ft. Then

$$F = \frac{30 \times 4}{\frac{25}{12}} = \frac{30 \times 4 \times 12}{.25} = 5,760 \text{ lbs.}$$

3. In the third question let us assume that the steam pressure is used mainly to raise the hammer and to keep it from rebounding at the instant of impact; to figure otherwise it would be necessary to have an indicator card from both ends of the cylinder, showing the back pressure as well as the forward pressure, throughout the stroke.

Assume the anvil to give one-sixteenth of an inch and the forging one-eighth of an inch; the total R = 3-16 = .19 inch.

Then
$$F = \frac{3 \times 1,500}{\frac{.19}{12}}$$

$$= \frac{3 \times 1,500 \times 12}{.19}$$

= 300,000 lbs. nearly, of which 100,000 lbs. will be absorbed by the anvil and 200,000 lbs. in changing the shape of the forging.

4. Consider first that the shaft be simply supported at the ends and loaded at the middle.

Then

$$W = S \frac{4 \times 3.1416 \times d^3}{32 \times L}$$

where W = load in pounds
S = breaking stress in lbs. per sq. in. = 130,000
d = diameter in inches = 22 in.
L = length between supports = 72 in.

$$W = 130,000 \times \frac{4 \times 3.14 \times 22 \times 22 \times 22}{32 \times 72}$$

$$= \frac{130,000 \times 4,179}{72}$$

$$= 7,540,000$$

Had the shaft been fixed at both ends and loaded at the middle. it would have taken twice the load to break it.

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60. Mr. E. P. W. writes: Please describe in your answers to "How and Why," the so-called compensating gear used on horseless carriages.

A. The use of the compensating gear is to reduce to a minimum the strains in the driving mechanism when the carriage is going around curves, in which case one wheel tends to turn faster than the other, and also to reduce the strains when one wheel passes over an obstruction in the road.

Fig. 3 illustrates the usual form of this gear. (D') is the axle passing through the gear and both wheels, (A) is the driving wheel and is driven from the engine by means of a chain or gear. Mounted in (A) is a small pinion (C). (B) and (B') are two bevel or miter wheels, and are fastened rigidly to the hollow shafts (D) and (d). The carriage wheels are fastened rigidly to the outer ends of these hollow shafts. The hollow shafts are free to turn on axle (D').

Now, then, when the carriage is running along a smooth straight road the wheels of the carriage will run at the same rate of speed, and will be driven through the hollow shafts (D) and (d) and gears (B) and (B'), and through pinion (C) and gear (A). In this case (C) will simply act as a driver, and does not revolve about its own shaft (EE'). However, as soon as one carriage wheel tends to run faster than the other, as in going around curves or over obstructions, then (C) will rotate more or less about (EE'), allowing extra motion to one or the other carriage wheel until the carriage moves in a straight line.

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61. R. H. S. writes: I would like to know if there is any way to solder aluminum by the use of a tinner's outfit or any other outfit.

A. In reply the writer would state that, so far, the finest mechanics in Cornell University have been unable successfully to solder aluminum. A tinner's outfit is no good for this work. The Pittsburg Reduction Co., Pittsburg, manufacture a solder and also a flux for this work. The writer would advise getting a sample of each from the company and trying them.

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62. H. A. writes: Is there any law, and in what State, regulating the lengths of exposed set screws on couplings, pulleys and the like machinery? If there be such a law, and it is not enforced, who is the proper person to apply to?

A. There is no law in regard to the lengths of set screws. It is a matter left entirely with the proprietor or owners of the plant. However, the law holds the owners of the plant liable for any accident arising from the use of dangerous machinery, and most rigidly so where such machinery has been condemned or brought to the notice of the foreman or superintendent prior to an accident.

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63. H. W. B. writes: I have a safety valve that was leaking, and I ground in its seat. Now, though it is tight, when closed it is not sensitive. It will open all right and will not seat without help when the pressure comes down. It is of the weighted lever type.

A. Probably when the valve was replaced after being ground in, a cramp or bind was introduced somewhere. See that the lever does not cramp in its guide or pins. Also be sure that the pin that holds the valve to its seat bears exactly in the center of the valve and that it does not have too blunt a point. If this pin does not bear exactly in the center of the valve it will make the valve tip when raised, and will force the guides on the lower side of the valve against their seat hard enough to give a certain amount of friction and prevent the valve closing. If, when the valve is acting as described, it will close when struck a few smart raps with a hammer it is a clear case of bind in some of its parts.